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CONTENTS.

ERRATA IN VOLUME X.

Page 166, line 2, *for* '238,959' *read* '224, 711.'

Page 229, *delete* par. 6, and *substitute* The Virgin Islands possess an Ordinance for fumigation similar to that of Dominica (see pp. 223-7)'.

Pages 240 and 268, and in legend of illustration facing page 268, *for* '*Sphaerostilbe flavidum*' *read* '*Sphaerostilbe flavida*'.

Pages 245 and 268, *for* '*Corticium lilaco-fuscum*' *read* '*Corticium lilacino-fuscum*'.

Page 269, par. 2, lines 1 and 2, *for* 'the nitrogen and phosphate series *read* 'Nos I and II.

Page 269, par. 3. lines 1 and 2, *for* 'the nitrogen series' *read* 'series No. 1'.

Page 341, line 3, *for* '*Brosimum alicastrum*,' *read* '*Artocarpus incisa*, var. *seminifera*'.

WEST INDIAN BULLETIN

VOLUME X.

THE FLOWER-BUD MAGGOT OF COTTON.

(*Contarinia gossypii*, Felt.)

BY H. A. BALLOU, M.Sc.

Cotton growers in Antigua suffered a serious loss in the amount of the crop of 1907-8, on account of the attack of a small insect of the family Cecidomyiidae. The insects of this family, the gall gnats and gall midges as they are called, belong to the natural order Diptera or two-winged flies. They are closely related to the mosquitos, the fungus gnats, and other small, frail flies.

THE CECIDOMYIIDAE.

The Cecidomyiidae are so small and inconspicuous as to be almost entirely overlooked except when they attract attention, either by the serious nature of the injury they do to agricultural crops, or by the curious appearance of the galls or swellings which some of them cause on the leaf, flower, stem, or root of various plants. Williston in his *Manual of North American Diptera* (1896) states that 'the family Cecidomyiidae includes a very large number of very frail, delicate, often very minute, flies, but is of the greatest interest to the biologist as well as the economic entomologist. At present about 600 or

700 species are known.' Kellogg in *American Insects* (1905) states that 'the gall midges are the smallest, frailest, and least conspicuous of all the flies, but their great numbers and vegetable-feeding and gall-making habits make them formidable enemies of many of our cultivated plants. About 100 species are known in this country [United States], and of these most are destructive to cultivated herbs, shrubs or trees.'

In the report of the New York State Entomologist for 1906, a list of new species of Cecidomyiidae appears which, it was stated, was published in advance of an extended monograph on this group of flies which was in preparation. This list contained 179 new species collected in New York State. This, it will be noticed, is more than all the species formerly known for the entire United States.

Mr. H. H. Smith, who collected for the Royal Society in St. Vincent, Grenada, and the Grenadines in 1888-9, took only seven species of Cecidomyiidae in St. Vincent, according to Williston's paper on the *Diptera of St. Vincent*, which is an account of the Diptera in Smith's collection.

Certain members of this family of flies are among the most serious of insect pests. Of these it is necessary to mention only one or two, to show how great damage to growing crops may be caused by species of these minute insects. The Hessian fly (*Cecidomyiia destructor*, Say) was probably introduced into the United States during the 18th century, perhaps during the war of the Revolution. It attacks wheat, principally, and, in a smaller degree, rye and barley, and other gramineous crops. The loss to American farmers is as much as $10,000,000 in a season.

In the *Journal of Economic Entomology* (Vol. 1, p. 18), Dr. E. P. Felt, New York State Entomologist, publishes a paper entitled 'Observations on the Biology and Food Habits of the Cecidomyiidae.' In this paper it is shown that the greatest divergence exists as to the effect on the host plant of these minute flies, between different species, and sometimes between the different attacks of the same species. Certain species produce very characteristic gall-like swellings on the plant which they attack, while in other instances no swelling is to be seen. This last is true of the three species in the West Indies. The red maggot of the cotton lives under the bark of the cotton plant without producing galls, but often killing all the plant above the point of attack. The flower-bud maggot of cotton causes the buds to drop, but no galls are produced, and the species recently discovered in mango kills the bark, resulting in the death of the small twigs, but without causing any conspicuous swellings. Members of the genus *Contarinia*, to which the flower-bud maggot of cotton belongs, are stated by Dr. Felt ('Observations on the genus *Contarinia*,' loc. cit. p. 227) to 'display a marked preference for florets, fruits or buds, *C. liriodendri* and *C. ananassi* being marked exceptions thereto, though the latter is more apparent than real, since the gall appears to be developed from the rapidly growing more tender portion of the twig, which is consequently allied to floral and bud tissues noted above.

'There seems to be no rule as to the number of generations produced annually by members of this genus. A few forms, at least, breed throughout the season, while others, apparently limited by conditions presented by the food plant have but one generation annually. This limitation of the number of generations by conditions of the food plant agrees with observations made upon better known species of the group such as *Mayetiola* (Cecidomyiia) *destructor*, Say.'

WEST INDIAN CECIDOMYIIDAE.

In 1903, the red maggot of cotton (*Porichondyla gossypii*) made its appearance in Barbados, and in 1907 the flower-bud maggot in Antigua. These are two new species, and recently (1908) another species has been reared from the dying twigs of mango, under the bark of which the maggots had been observed. This has not yet been identified, but it will probably prove to be a new species, and its occurrence may account for the dying-back which has been noticed from time to time in the tips of twigs of mango, especially of the grafted varieties.

The flower-bud dropping of cotton was first brought to the attention of the Imperial Department of Agriculture in January 1908, when Dr. F. Watts forwarded from Antigua, specimens of the insects and of infected flower-buds of cotton. These were exhibited at the West Indian Agricultural Conference at Barbados, and it was stated that they were of the family Cecidomyiidae, nearly related to the red maggot (*Porricondyla gossypii*), but of a different species.

FLOWER-BUD MAGGOT, 1907-8.

It had been noticed on certain estates in Antigua during November and December that no flowers were being developed on the cotton in certain fields. This led to examination, with the result that the flower-buds (squares) were discovered to be falling, and many young bolls (forms) also. On January 4, the small reddish-yellow maggots were discovered at Blubber Valley estate by Mr. S. Smith the manager. Following on this, a survey of the island was made by Mr. T. Jackson, Curator of the Botanic Station, with the result that it was found that this maggot occurred in all parts of the island, and on nearly every estate. Mr. Peters, proprietor of Blubber Valley, and Mr. Smith a few days later made similar visits of enquiry and confirmed Mr. Jackson's observations.

FIG 1. *Contarinia gossypii*, Felt.
The larva or maggot enlarged about 30 diameters (original).

The Entomologist visited Antigua during February and spent about two weeks in a preliminary investigation, and another visit was made from March 7 to April 3. The information on which this account is based, was obtained during these two visits.

At the time of the first visit (February) the infestation in certain fields was as high as 100 per cent.; that is to say, that during a period of several weeks no bolls were formed on the plant. A few buds remained long enough for the flowers to open, but the injury to the essential organs had been so great that fertilization could not take place and the young bolls dropped without making any development.

In February, many fields were seen in which no flowers were opening: buds were being formed freely, but these were dropping as fast as they were formed, and while they were quite small. A few of the earliest had succeeded in forming bolls, and these were to be seen in the first two or three axils on the lowest lateral branches. At this time many of these plants should have had eighty or ninety bolls each, and most of them fifty or sixty, at the very least.

In March, on the same fields, many of the buds were escaping the attack and the few bolls (formed in November) were beginning to ripen. These fields had lost about four months of bearing. During the month of March the attack continued, becoming less and less severe, until with the continued dry weather it disappeared entirely in April.

It has already been stated that the attack of the flower-bud maggot was first noticed at Blubber Valley estate. The field in which the flower-bud dropping was so excessive as to attract attention was 9 acres of very healthy, well-grown cotton, which was planted in September. The following notes on this field, which is designated as No. 10, and others under the same management, together with notes on weather conditions were furnished by Mr. S. Smith the manager of the estate.

The Weather at Blubber Valley.

'During June and July 1907, there were regular showers and sunshine. A period of drought which extended through August into September was broken by the gale of September 11. Wet weather followed, which without giving a very heavy rainfall, maintained a condition of dull, damp days, and in November and December the nights were chilly.

Planting at Blubber Valley.

'Planting began in June. The plants grew well, bolled freely, and no dropping of bolls was seen. The plants were somewhat injured by the gale of September 11, and new shoots were developed. These grew rapidly and greatly thickened up the plants. The bolls from the first flowering did not ripen and open properly, so that much of the cotton spoiled. This might have been due to the moist condition and lack of sunshine that prevailed for some time after the gale.

'The cotton planted in July grew well, bolled freely and gave a yield of about 150 lb. lint per acre, with a promise of a good second picking.

'The dry weather of August resulted in very bad germination. With the advent of rains in September, planting was pushed forward. The seed grew well, and the appearance of the plants indicated that a good crop would be produced.

'It was noticed on December 7, 1907, that buds and young bolls were dropping. The young bolls (forms) were seen to be unfertilized. On January 4, 1908, the flower-bud maggot was discovered, and it was noticed that whenever the bracts were found to have flared back, the bud was infested no matter how fresh it might appear.'

It will be seen from these notes that the cotton planted in June and July experienced dry weather for about six weeks during August and the early part of September. It might be added that the cotton planted in September, in addition to the wet weather of the latter part of September and October, came in for a period of weather, which without any very heavy rainfall was very damp with but little sunshine. This condition lasted through October and extended into November. Field No. 10, in which the flower-bud maggot was first discovered, and which suffered the heaviest possible infestation, was a level field of bottom land with a tendency to dampness. The soil of this field is classed as a medium sandy loam with a heavy subsoil. It is the sort of soil that gives vigorous growth of crop and of weeds in ordinary years, and in 1907 was distinctly moist during the last three months of the year.

Although this field was the first in which the flower-bud maggot was discovered, all fields in the island in which the cotton was in a condition for flowering during this damp period were found to be attacked.

LIFE-HISTORY OF THE INSECT.

The egg of *Contarinia gossypii* has not been discovered. It is probably inserted into the tissues of the flower-bud by the female fly, by means of the thread-like ovipositor (see fig. 5).

The larva when first hatched from the egg is very minute: when full-grown it measures about 2 mm. ($\frac{1}{12}$ inch) in length. The newly hatched larva is white, but during its life and growth gradually becomes first creamy, then yellowish, and, when about to pupate, slightly pinkish yellow, varying to orange.

The maggots are to be found in the flower-bud of cotton amongst the essential organs. When very young buds are attacked the injury is so severe as to cause them to fall off, but larger buds seem to be better able to withstand the effects of the attack, according to size. It seems probable, however, that although an attacked bud may develop into a flower, the bolls from such flowers never develop.

In cases of severe attack by the flower-bud maggot, the very smallest buds are infested—in fact, at Blubber Valley in

February 1908, in field No. 10, very few of the buds developed beyond the earliest stages, for several weeks.

In other instances, it was found that many buds, probably attacked later in their growth, were able to develop almost to the size of the normal flower, but they were unable to open fully, and no bolls resulted from such buds. When the very small bud is infested the bracts surrounding it flare back instead of remaining closed. Buds, the bracts of which are flared, are always found to be injured, and generally to contain the flower-bud maggot, and such buds invariably drop very soon after the flaring. It has been found, however, that buds which have been eaten into by caterpillars such as the cotton worm (*Alabama argillacea*), and the dark cut worm (*Prodenia ornithogalli*) show flared bracts: but the instances of this kind of injury are not common.

It is believed that the maggots live and feed among the developing anthers in buds of all stages, but when the buds drop or are picked off the plant, they very soon leave their feeding places and depart from the bud, the full-grown maggots to pupate in the ground, and the younger ones apparently to find fresh feeding places.

Although these maggots have no legs or feet, they are very active and seem able to crawl and climb well. When a small bud is cut open the anthers are seen as a compact mass, and any maggots among them are difficult to distinguish with the unaided eye, and sometimes even with the aid of a good lens. Almost immediately, however, on the cutting of the bud, the maggots begin to appear, evidently disturbed by the exposure to the light. Not only do they wriggle about actively, thus distinguishing themselves from the anthers, but when they get to the surface they are seen to jump or spring off into space. This jumping is accomplished by the maggot bringing the two ends of the body together, and then straightening out suddenly. This is characteristic of the larvae of the family Cecidomyiidae, and by this means they are able to cover considerable distances, in proportion to their size.

The mouth parts of the flower-bud maggot have not been studied, but they appear to be soft and without the hard and chitinous development which occurs in the mandibles of the larvae of butterflies and moths (caterpillars) and of beetles (grubs), which bite off particles of food, and in the beak or rostrum of the Hemiptera, such as plant lice, scale insects, and cotton stainers, which pierce plant tissues and suck out the juice. The caterpillars of butterflies and moths, and the grubs of beetles are able to eat such hard substances as leaves, bark, sap-wood, and heart-wood of growing trees and other plants, and certain of them, specially among the beetles, are able to bore into dry, cured wood, and leather, upon which they feed. With the larvae of the Cecidomyiidae, however, it is different. The species known in the West Indies live only on the tenderest plant tissues. The red maggot of the cotton lives in the cambium layer, as does also the maggot which attacks the mango. The flower-bud maggot living among the developing stamens, feeds on the anthers, which are also very tender tissue,

In both these situations also, the larvae are able to feed on the richest and most nourishing tissues produced by the plant.

FIG 2. *Contarinia gossypii*, Felt.
The pupa-case enlarged about 30 diameters (original).

The pupa of *Contarinia gossypii* is formed in the ground probably not more than an inch below the surface. The pupa is not known, but the empty pupa case has been found and photographed (see fig. 2).

The flies do not live long after emerging. In captivity they die in two or three days. It is not known whether more than one female oviposits in the same bud, but this seems likely, since as many as forty-three larvae, varying greatly in size and development have been counted in one bud.

The appearance of the male and female fly is shown in the accompanying figures.

FIG. 3. *Contarinia gossypii*, Felt.
The fly, female, enlarged about 25 diameters (original).

The length of life cycle of this insect is not definitely known. The eggs and larval stages together probably occupy about twelve to fourteen days, the pupal from ten to fourteen or even more, and the adult two to three days. This would give an entire life cycle of from twenty-four to thirty-one days.

FIG. 4. *Contarinia gossypii*, Felt.

The fly, male, enlarged slightly more than fig. 3.

Specimens of the adult insect mounted in balsam were forwarded to Dr. L. O. Howard, Entomologist, U.S. Department of Agriculture, who sent them on to Dr. E. P. Felt, New York State Entomologist. Dr. Felt described them and established a new species of the genus *Contarinia*, to which he gave the name *Contarinia gossypii*.

From Dr. Felt's description (see p. 13) it will be seen that the male adult fly (fig. 4) is 1 mm. ($\frac{1}{25}$ inch) in length, and the female (fig. 3) 1·5 mm. ($\frac{1}{18}$ inch) in length.

The female has a spread of wings of about 3 mm., and the full-grown larva (fig. 1) is from 2 to 2·25 mm. in length.

NATURAL ENEMIES.

In all the cotton fields in Antigua where the infestation of *C. gossypii* was noticed, there were to be seen on nearly every flower-bud and flower, small wasp-like insects belonging to the parasitic Hymenoptera. They were always walking about over the flower buds, generally rapidly touching the surface with the tips of the antennae, and one of these insects was observed to arch its body and bring down the tip of the abdomen as if ovipositing. This was accomplished so quickly, however, that it was over and the insect had moved on before a lens could be brought to bear on it. Dissection of the bud later in the laboratory failed to reveal the egg.

Some of these insects were among the first specimens of the flower-bud maggot received from Dr. Watts in January 1908, and were sent on to Washington at the same time, where through the kindness of Dr. Howard, Mr. J. C. Crawford identified them as *Sactogaster rufipes*. Dr. Howard states that *Sactogaster rufipes* may very probably be a parasite of this Cecidomyiid, since related insects are parasites of Cecidomyiidae.

FIG. 5. *Contarinia gossypii*, Felt.

Tip of abdomen of female fly, showing threadlike ovipositor greatly enlarged (original).

Additional specimens of these parasitic insects were sent on later, being numbered 901 and 902, and Dr. Howard stated in regard to them: 'No. 901 seems to be a *Catolaccus* or something very closely allied to it, and is a primary parasite of the Cecidomyiid. Under 902 of course you have something quite different. . . . . It comes close to *Leptacis*. These parasites infest Dipterous larvae. Therefore I think it is a primary parasite, not a secondary.'

It will be seen from these remarks that probably there are at least three species of parasitic insects occurring in the cotton fields of Antigua—*Sactogaster rufipes*, *Catolaccus* sp., and *Leptacis* sp., and they probably exercised a considerable influence in bringing the attack to a close.

In many of the breeding jars in which the flower-bud maggot was kept under observation in the laboratory at Antigua, specimens of these parasites were frequently found. In one instance the parasite larva was found attacking the flower-bud maggot. The parasite, which was as large or perhaps a trifle larger than the maggot, was attached by its mouth parts and appeared to be extracting the body contents from the maggot. Previous to this a considerable number of maggots had been found nearly lifeless and quite limp and flaccid, indicating plainly that they had been injured in some way. Although this parasite larva was not identified, the writer believes that from its size it must have been No. 901, *Catolaccus*.

Even in the most seriously infested fields the adult of *Contarinia gossypii* was very difficult to find. In sweeping with the net, hundreds of small insects of many kinds were caught, but it was very rarely that *C. gossypii* could be taken

in this way. Various baits and light traps were tried but none were successful.

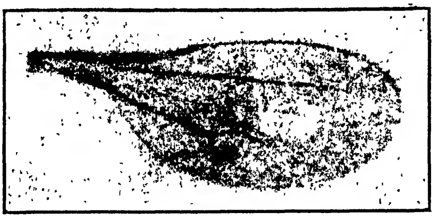

Fig. 6. *Contarinia gossypii*, Felt.
A wing enlarged about 45 diameters (original).

Experiments in control of attacks of flower-bud maggot were established in March 1908, but no results were obtained. This was probably due to the fact that the attack was decreasing in severity at the time, and that the dry weather which set in soon after stopped the growth of the plants, and they made no further attempt to put out blossoms.

Many flies and other insects are frequently to be seen in the flowers of the cotton plant, and these have been mistaken by planters for the parent of the flower-bud maggot. These insects are common flower visitors, several species of flies, including a species of *Drosophila*, being frequently seen in a great variety of flowers. A small bug (Hemiptera), a Staphylinid beetle, and one or more species of thrips are to be found in nearly every open cotton blossom. The writer has examined in the field hundreds of blossoms and buds in all stages of development, and has not seen the adult *C. gossypii* in, on, or about them

Contarinia gossypii, Felt.
Portion of foot of fly greatly enlarged (original).

Extract from a Report by the Entomologist on the staff of the Imperial Department of Agriculture.

I have the honour to submit a brief report on my visit to Antigua from February 9 to 25, to make a preliminary investigation of the flower-bud dropping of cotton in that Presidency.

This, it is believed, was first noticed by Mr. Sydney Smith of Blubber Valley, in December last. The flower buds were dropping in enormous numbers, and on cutting them open some of these maggots were discovered inside.

The maggots were sent to Dr. Watts on January 6, who forwarded a portion of the infested material to this office. From this material a few flies were obtained and shown at the Agricultural Conference at Barbados where I stated they were different from the red maggot of the cotton in Barbados, but probably closely related. This has been confirmed by Dr. Howard, Entomologist to the United States Department of Agriculture, to whom a few specimens had been sent for identification. Dr. Howard reported that the specimens were badly broken on arrival but that they seemed to be a species of the genus Cecidomyiia. This genus is related to the red maggot (*Porricondyla gossypii*). Further material will be submitted as soon as available, in order to obtain a more definite determination.

The situation in Antigua is a serious one. The pest occurs in all parts of the island and probably in every cotton field. Mr. T. Jackson made a tour of the island and found the flower-bud dropping in all localities, and in most cotton fields. In the fields where Mr. Jackson failed to find it on his first visit, the pest has developed since.

During my stay in Antigua I visited the estates at Jolly Hill, Blubber Valley, etc., under Mr. Smith's management, as well as all the cotton fields in the vicinity of St. John's in the Pope's Head district, and at Yepton's, and I found the same conditions prevailing in greater or less degree in all the cotton fields.

Most of the cotton planted previous to August 15 has made a crop, while most of that planted after September 1 will, it is feared, give but little cotton, and certain fields will give practically none.

In late planted fields, I noticed that a few bolls were found on the lower laterals, and that the remainder of the plant was without flower or boll. This would indicate that the attack of the pest began soon after the plants commenced to flower.

The attack is made on the very young buds. I was not able to find in any instance buds that were too small to be infested.

I have not been able to investigate the periods of the several stages in the life-history of the insect, nor have I so far been able to find the eggs, or to see the insects actually attacking the buds, and ovipositing in them.

I agree with Dr. Watts that this is a pest of prime importance as affecting the success of the cotton industry at Antigua, and that it is essential that every detail of the life-history and habits of the fly should be ascertained before practical measures can be taken to deal with it.

It is necessary also that action should be taken at once, for although it may not be possible to save any considerable part of the cotton crop at present attacked, the plants now growing, and the insects on or in them, should be used for experiment and observation in order that we may be in a position to make recommendations in anticipation of next planting season.

Extract from a Report by the Entomologist on the staff of the Imperial Department of Agriculture.

I arrived in Antigua on March 6, after being absent from the island two weeks, and left, to return to Barbados on April 4.

On arrival at Antigua I found that considerable improvement had taken place in the cotton fields. Some of these, which only a fortnight previously had not a flower on them, were beginning to bloom freely. This improvement continued throughout the time of my second visit until, at the time of my departure, the pest had practically disappeared and the boll-dropping ceased in most fields. An exception to this was to be found in one field at Blubber Valley, where infestation of young buds continued to a very slight extent.

I devoted myself to a study of the insect, in order that I might get as much information as possible, and a few experiments were established. As a result of this study, it appears that the maggots leave the bud soon after it falls, and go into the ground to pupate. The pupa is naked, the pupal covering very thin and delicate, and pupation is carried out some 1 or 2 inches beneath the surface. The duration of the pupal stage is about ten to fourteen days.

The flies live but a few days after reaching the adult condition. The female punctures the tissue of the bud with the ovipositor, and inserts the eggs. Probably several females oviposit in the same bud. I have found as many as forty-three maggots in one bud, and these of such varying size as to indicate several depositions of eggs. The length of time taken for the eggs to hatch, and for the maggots to become full-grown has not been ascertained, but the indications are that it is very short, probably not much more for eggs and larval stages together than is required for the pupal stage. If this supposition is correct, the total length of time required for the life cycle is about four weeks.

As stated in the report on my visit to Antigua in February, most of the cotton planted previous to August 15 made a fairly good crop, while most of that planted from the first of September did not give a crop. A few of the earliest blossoms on September cotton escaped attack, and again blossoms escaped in early February. The former of these gave a few bolls which were ripening in March. The few flowers which escaped attack in February resulted in bolls, which at the beginning of April had made good development.

The first indication of the presence of the disease in Antigua was the excessive dropping of the buds. Then it was found that in the case of many of the buds, the bracts, instead of remaining closed (adpressed) around the bud had flared out in a striking manner, and on examination it was found that all buds with 'flared' bracts were infested, and I later discovered by examination of large numbers of buds, that nearly all infested buds become 'flared' before dropping.*

The conditions which led up to this remarkable and very serious outbreak of this new pest can only be surmised, but

*See Fig. 8.

from the evidence at hand, it would seem that the surmise is well founded.

In the first place, the pest is probably a native of Antigua, or at least not a recent importation. This is borne out by the fact that it appeared in all parts of the island almost simultaneously, and with a uniform degree of severity. The fly is very fragile and probably not capable of any long flight, nor of being carried far by the wind. Secondly, the weather conditions in Antigua have been rather unusual for the past eighteen months. Beginning with the very heavy rainfall of September 1906, Antigua has experienced wet and damp weather in rather an unusual degree in many parts without perhaps recording a rainfall much, if any, above the average. This dampness with the stronger growth of the plants, the moister soil, and the great tendency to weeds in the fields, gave the maggots as they fell to the ground a better opportunity of pupating than under the normal conditions in Antigua. It was noticed on several estates that cotton fields, in which there was a tendency to damp soil and a strong vigorous growth of plants which covered the ground, were more severely attacked than the fields in which the soil was drier and the plants smaller; and when, as sometimes happened, there was a strong tendency toward a rapid growth of weeds on the damp soils, the difference was more noticeable.

Two small insects which belong to the parasitic Hymenoptera were very common in all infested cotton fields. One of these I found to be a very active enemy of the maggot in the flower bud, and I believe the other to be the same, but I have not yet proved this point.

It is likely that the sudden improvement in the condition of the cotton fields and the almost total disappearance of the maggots are due to the drier weather, and hot bright suns of February, together with the beneficial effects of the parasitic enemies of the maggots.

Up to the present time no remedial measures have given definite results. Experiments have been tried and it is hoped that they may give results that will be useful. The use of vaporite seemed likely to be beneficial, and several applications of this material have been made. Vaporite is a proprietary material sold by Strawsons & Co., England. Its object is the killing of insects in the soil, and it was hoped that during the time when the maggots and the pupae were in the soil, the effect of the vaporite fumes would be sufficient to kill most of these insects.

Cultural methods may reduce the loss from this form of flower-bud dropping. Any system of planting and tillage which allows the sun to get freely to the ground around the plant, and which keeps the surface thoroughly pulverized, dry, and free from weeds, would seem likely to be useful. Wet weather, damp surface soil, and the presence of weeds seem to be favourable to the increase of the pest.

From the *Entomological News*, May 1908, p. 210.

CONTARINIA GOSSYPII, N. SP.

BY E. P. FELT, ALBANY, N. Y.

This species is injurious to cotton in the British West Indies, and was received from Mr. Henry A. Ballou, Entomologist to the Imperial Department of Agriculture, Barbados, through Dr. L. O. Howard, at whose request it is described :—

Male.—Length 1 mm. Antennae about twice the length of the body, thickly haired, light brown, fourteen segments; the first broadly obconic, the second flattened basally, subhemispheric; the others, binodose, the third and fourth slightly fused, the fifth having the basal portion of the stem with a length three times its diameter, the distal part with a length four times its diameter; the enlargements with the membrane thickly dotted with chitinous points; the basal one subglobose, flattened basally, with a sub-basal whorl of long, stout setae and a subapical circumfilum; the loops of the latter long and extending to the middle of the distal enlargement, which latter is slightly produced, broadly oval, with a thick whorl of long, stout, curved setae near the middle and a subapical circumfilum, the loops of the latter distinct and extending to the middle of the basal enlargement of the following segment; terminal segment with the basal enlargement subglobose, the basal portion of the stem somewhat produced, slender; the distal enlargement slightly produced and bearing apically a long slender finger-like process. Palpi quadriarticulate; the first segment apparently short, stout, irregularly subquadrate; the second a little longer, broadly ovate; the third fully half longer than the second, more slender; the fourth as long as the third, more slender, all rather thickly clothed with coarse setae. Face fuscous, yellowish, eyes large, black; mesonotum dark-brown, the submedian lines yellowish; scutellum fuscous yellowish: postscutellum yellowish; abdomen greenish-yellowish; the segments posteriorly rather thickly margined with coarse setae; wings hyaline, costa pale straw; subcosta uniting with the anterior margin near the basal third, the third vein just beyond the apex, the fifth joining the posterior margin at the distal fourth, its branch near the basal third; membrane sparsely clothed with fine hairs. Halteres presumably yellowish transparent, coxae yellowish, femora, and tibiae pale yellowish straw, tarsi slightly darker. Claws long, slender, evenly curved, simple, the pulvilli a little shorter than the claws. Genitalia; basal clasp segment rather long, broad, tapering to a narrowly rounded apex; terminal clasp segment long and tapering slightly to an obtusely rounded apex. Dorsal plate and other minor organs indistinct in the preparation.

Female.—Length 1·5 mm. Antennae about as long as the body, sparsely haired, pale yellowish, fourteen segments; the first broadly obconic, the second somewhat produced, broadly fusiform, the others cylindric, the third and fourth slightly fused; the fifth with a stem about one-fifth the length of the subcylindric basal enlargement, which latter has a length

nearly two and a half times its diameter, the membrane thickly dotted with chitinous points, with a thick sub-basal whorl of long, stout, curved setae, and a scattering subapical band of shorter curved setae; low circumfili occur near the basal third and apically; terminal segment strongly produced, the distal enlargement with a length about four times its diameter and distally tapering to a narrowly rounded apex. Palpi quadriarticulate; the first segment irregularly fusiform; the second narrowly oval and half longer than the first; the third half longer than the second, more slender; all rather thickly clothed with coarse setae. Colorational characters about as in the opposite sex, except that the abdomen appears to be a fuscous greenish-yellow and the posterior margins of the segments, especially the apical ones, are more thickly clothed with coarse setae; tarsal characters as in the opposite sex. Ovipositor yellowish, probably nearly as long as the body when extended, the terminal lobes very long, slender, having a length fully five times the width and tapering to a subacute apex bearing a few short, stout setae subapically.

Described from a number of specimens recently mounted in balsam.

Types, C. 1,331, deposited in the U.S. National Museum and New York State Museum.

THE FLOWER-BUD MAGGOT OF COTTON.

OCCURRENCE IN 1909.

Extract from Report of Entomologist on a visit to Antigua in connexion with the reappearance of the flower-bud maggot.

I arrived in Antigua by the R.M.S. 'Eden' on January 8, and embarked for Barbados on February 6.

One object of the work of investigation was to discover, if possible, the plant or plants other than cotton (wild or cultivated) in which the flower-bud maggot may live and breed. In the report on my visit to Antigua in November, it was stated that both Mr. C. W. Jemmett and myself had made careful search for this insect but did not succeed in finding it, though Sea Island cotton was examined in several fields, and the wild cotton at Judges (Blizzards).

On my arrival at Antigua, one of the first things I did was to visit the wild cotton mentioned above, and the flower-bud maggot was at once found in considerable quantity.

Examination of other plants, then in blossom in the immediate vicinity, led to the discovery of a Cecidomyiid larva in the flower-buds of the Privet or Wild Coffee (*Clerodendron aculeatum*). I was not able to determine whether this was the same as the flower-bud maggot of cotton by comparing the maggots, so I collected a large quantity of flowers and buds of the plant from the hedge surrounding the Botanic Station. These were placed in breeding jars at the laboratory, and from them I reared two (or three) different Cecidomyiid flies, one of them apparently identical with the fly which is the adult of the flower-bud maggot of cotton.

In order to obtain further proof as to the identity of this insect, experiments have been started at the Botanic Station, with the object of producing an attack of flower-bud maggot on cotton directly from the insect in the flowers and buds of the Privet. This experiment is not finished.

In connexion with this portion of my work, the flowers and flower-buds of some eighty-four different species of plants have been examined, and two or three lots of some of them. I am indebted to Mr. Jackson for having most of these collected by persons connected with the Botanic Station.

The experiments started during my visit to Antigua last year gave no definite results, perhaps because the attack of the flower-bud maggot was on the decrease at the time the experiments were started, and perhaps because of the drought which set in soon after, and stopped the flowering of the plants.

Similar experiments have been started again and are at present in progress. These may give results later, which will suggest direct remedial measures.

These experiments are established in two places. There are five plots in the field of cotton at the Old Hospital, each about $\frac{1}{10}$ acre, which received the following applications: No. 1,

sulphate of ammonia; No. 2, sulphate of potash; No. 3, vaporite; No. 4, nitrate of soda; No. 5, vi-phosphate. These plots were established with the consent of Mr. Fisher, who detailed officer Maynard to assist in carrying out the work. At Mc Kinnon's there are seven plots, established with the consent and co-operation of Mr. J. Roden, and the active assistance of Mr. Hallpike. These plots are about $\frac{1}{12}$ acre, and received—No. 1, sulphate of potash: No. 2, sulphate of ammonia; No. 3, nitrate of soda; No. 4, superphosphate; No. 5, vaporite; No. 6, vi-phosphate: No. 7, salt. In both these series the applications consisted of 20 lb. of each substance, except McKinnon's No. 7, to which only 10 lb. of salt were applied.

Previous to my arrival in Antigua, Dr. Watts had given Mr. Robert Goodwin 100 lb. of vaporite for use at Grey's, where the flower-bud maggot had made serious attack. This amount of vaporite was applied to 1 acre of cotton, and at the time of my visit to this estate (Feb. 2), the cotton field treated with vaporite showed a greater proportion of flowers than any other field on that estate, and it was decided that it would be worth while to make a more extended trial of this material. With this end in view, Mr. H. A. Tempany, Acting Superintendent of Agriculture, sent out a circular letter to a limited number of representative planters, asking if they wished to make a trial of vaporite, and offering 100 lb. of this material to each one, with directions for applying it.

In combating insects closely related to the flower-bud maggot, it has been found that applications of mineral fertilizers have been decidedly beneficial not only from their usefulness as manures, but from the action on the insect, of the mineral salts in solution in the soil. What effect these may have on the flower-bud maggot is very problematical, but they are considered to be worth the trial.

I noticed that the parasitic Hymenoptera which were abundant in February and March 1908, were much less numerous during January 1909.

In nearly all the cotton fields I visited, I noticed that the youngest bolls on many of the plants must have been formed about the middle of December. That is to say, the attack of the flower-bud maggot must have become sufficiently severe about that time to prevent the development of flowers and bolls, and for the most part there had been no bolls developed from that time up to the first week in February. In most cotton fields, the fallen flower-buds were not so numerous as the small bolls or forms which appeared to have dropped within two or three days of the opening of the flower and the shedding of the corolla. I do not feel sure that I should be quite correct to lay all that to the charge of the flower-bud maggot. The shedding of the corolla is a perfectly normal circumstance, but the dropping of the bolls is abnormal. Whether these bolls were dropped because they were unfertilized I cannot say, but I believe that many of them were. Further, I cannot say whether they were unfertilized because the flower-buds from which they were being developed suffered attacks from the flower-bud maggot; but I believe that most of them were unfertilized as a result of these attacks.

As already stated, very few bolls were developed from the middle of December to the first week of February, and as a consequence, the top of the plants for some 12 to 18 inches, with the developing laterals from this amount of growth, was quite unproductive of bolls, and I believe that most of this was due to the flower-bud maggot.

In past years, the dropping of these very small bolls has been ascribed to the weather, and in a sense this may be correct, for there seems to be a definite relationship between certain weather conditions and the attacks of the flower-bud maggot. For instance, the flower-bud maggot appears to begin its attack with the advent of cold nights, or nights with heavy dew, or during any period when the chill winds are from an unusual quarter, and the severity of the attack seems to vary within a very short time with changes in the weather.

During my stay in Antigua I visited cotton fields in the north of the island, at High Windward, and in the Valley district. With the exception of Cade's Bay and Orange Valley estates, the cotton in all fields presented the same general features, but in the fields of the two estates mentioned, there was an abundance of flowers and young bolls, and an almost total absence of the flower-bud maggot. At Cade's Bay, I found maggots in one bud and saw a few that I judged to be attacked, but when I reached Orange Valley, I could not find the maggot, though I found many bolls, which from their appearance I should have judged to be infested. Mr. Pateson told me that that had been his experience for the entire season: he had frequently found buds which appeared to be infested, but had not found the maggot.

After coming to the conclusion that the flower-bud maggot of cotton infests the flowers and buds of Privet, I was constantly observing the wild plant growth, trying to get as good an idea as possible of the distribution of this plant. I should say that in most parts of the island, Privet is more widely distributed and more abundant than almost any other woody plant, either tree or shrub; but that in the Valley district, from Jolly Hill to Cade's Bay, it seems to be much less abundant. There may be some connexion between the comparative freedom of Cade's Bay and Orange Valley from the flower-bud maggot, and the smaller amount of Privet in that district.

In the matter of remedial measures, and measures of prevention, I am of opinion that it is essential to remove all wild cotton from the vicinity of cotton fields at the time of planting, and that at the beginning of an attack of flower-bud maggot, much may be accomplished by hand-picking the infested bolls, which are indicated by the flared bracts.

When the attack becomes general, this may not be profitable, and it may be found best to discontinue hand-picking of infested bolls. The planter should, however, be able to judge as to this. If it is proved later that the infestation can be conveyed directly from the Privet to the cotton, it will probably pay to cut down and burn all Privet near the fields to be planted.

The experiments now in progress at Antigua may give results that will suggest other lines of action against the attacks of the flower-bud maggot, but the foregoing recommendations are all that can be made at present.

FIELD NOTES, 1908.

At Blubber Valley several rows of cotton were cut out on February 14, 1908. On the morning of the 15th, I counted all the buds on two of those cut plants; one had thirty-five buds, of which seven were apparently good, and twenty-eight severely attacked; the other had twenty-six buds, of which two seemed to be all right and twenty-four were attacked. Mr. Peters removed all buds showing signs of attack from an average plant; three days later about twenty more showed signs, and were removed, and in another three days about twenty more. So that upwards of forty buds had been attacked on one plant in less than a week.

In a small plot of cotton on Gamble's estate near Government House, I counted, on one small plant forty buds, twenty of which were obviously attacked. At the Old Hospital, I found from three to ten attacked buds on each of the plants counted. There were no bolls except near the ground: all buds formed for some six to eight weeks had been shed.

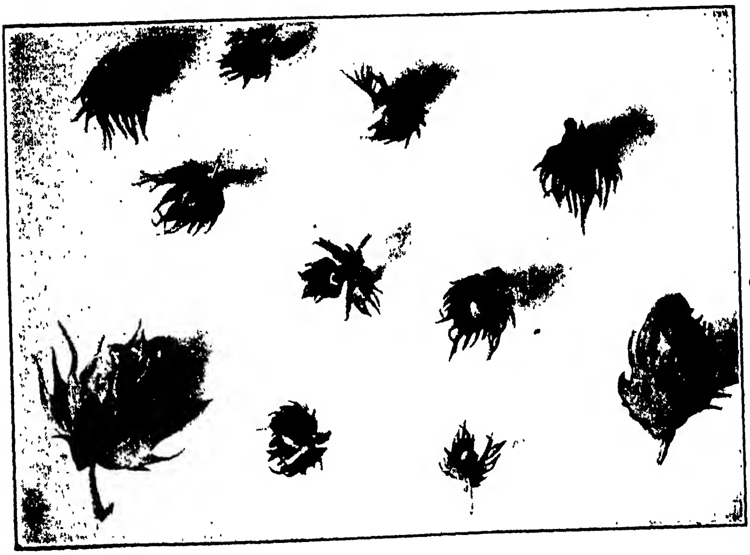

FIG. 8.

Infested flower-buds of cotton showing characteristic flaring of the bracts of the small buds. The larger buds were attacked at a later stage of development and remained on the plant until the corolla was almost full-grown. The flaring of the bracts was considered evidence that the bud was attacked. (Original.)

Infestation does not seem to be much influenced by having wild land, or cotton, wild or cultivated, near the fields; nor does it depend on whether the cotton is grown on land previously occupied by cotton. Blubber Valley had previously no cotton in the vicinity of the fields which were, in 1907-8, most seriously attacked. At Gravenors and Thibou's, on 6 acres of good, healthy, well-grown cotton, there were, in March

1908, no bolls and very few flowers. This field was in cotton for the first time. It was on land occupied by cane in the previous season, and there was very little wild land near.

REARING RECORDS, 1908.

When about to leave Antigua for Barbados on February 22, I left infested material in a box (A) provided with about 2 inches of soil in the bottom and six glass tubes let into the side. It was hoped that the cecid flies and other insects as they emerged would enter the tubes, from which they might be removed.

Two boxes (B 1 and 2) were prepared by Mr. Tempany, each with soil and one glass tube in the side. Three series of jars with soil were supplied with material and labelled C, D. and E.

FIG. 9.
Flower-buds and flowers of cotton showing normal position of bracts and a normal flower. (Original).

A. This box received young buds taken from the plants. *Collected February 16 and 18.* February 26, one parasitic Hymenoptera (901). March 1 and 2, four cecid flies. Finished March 10.

B. 1. The material in this box was young buds taken from the plants *Collected February 26 and 27.* No results.

B. 2. The material in this box consisted of older buds, in which corolla was half to two-thirds developed, showing by colour or shape of corolla that they are infested. *Collected February 26 and 27.* This box yielded no cecids and no parasites.

C. These jars received young buds taken from the plants. Numbers 1, 2, and 3.

(1) *Collected February 27.* March 8, about forty cecid flies; March 9, about twenty cecid flies; March 16, several cecid flies had been present all the time during the week.

This jar was used from the 9th for infestation experiments. A branch of cotton with a few small buds was placed in the jar and the whole covered with a bell glass. No results. The cecids began to die in two days; several died each day until Saturday. March 16, all old cotton buds taken out of the jar leaving the soil to see if more cecids would emerge, but nothing further was obtained.

(2) *Collected March 2.* March 10, several larger parasites (902). March 16, nine parasites (901).

(3) *Collected March 6.* March 16, took out several full-grown larvae, two parasites (901). March 22, few cecids, three parasites (901).

D. Into these jars older buds were put, also taken from the trees.

(1) *Collected February 27.* March 10, several cecid flies. March 16, this jar has been giving a few cecids all along. Saturday 14, started an experiment with several substances--kerosene, bay oil, lemon grass oil, oil of cloves, sugar and water, molasses, and flour paste. None of these substances attracted the flies, and the experiment was without result. Several larvae still alive on sides of jar. Took two small parasites this date (902).

March 17, ten small parasites (two 901, eight 902). March 18, seventeen small parasites (nine 902). March 21, four small parasites, ten small moths.

(2) *Collected March 2.* March 10, four larger parasites (901). March 16, several parasites (901)

(3) *Collected March 6.* March 17, two parasites (901). March 22, six parasites (901).

E. These jars received young and older buds which were taken from the ground.

(1) *Collected February 26.* March 8, two parasites (901).

(2) *Collected March 1.*

(3) *Collected March 6.* March 17, four parasites (901), March 22, one cecid.

From these notes it will be seen that the box type of rearing cage was not successful, and that from material collected from the ground only one adult cecid was reared. It is further shown that practically no cecids were reared from cotton flower-buds collected after Feb. 27 in these trials.

Material collected from Sea Island cotton on several estates and from wild cotton, in widely separated localities on March 6, 14, and 18, gave no cecid flies although maggots were seen when the material was collected.

This is in accordance with the general statements made in this paper that the maggots leave the buds as soon as they drop, and that the attack had begun to decrease in severity in March, and the proportionate increase in the number of the parasites would indicate that these useful insects were directly concerned in the diminution of the flower bud maggot.

FIELD NOTES, 1909.

On arrival in Antigua on January 8, I was informed by Dr. Watts that up to December 31, the flower-bud maggot had not been reported from Yepton's, Thibou's, Tyrell's, Old Hospital, Sion Hill, Cade's Bay, or Orange Valley, and that it had only slightly attacked the cotton at Gamble's, the Experiment Station Skerrett's, and Colebrook's. It was stated not to be increasing at Parson Maul's, or Gray's.

On January 2, it was reported from Tyrell's and Cocoa-nut Hall. On January 9, I visited the wild cotton at Judges, where Mr. Jemmett and myself had made a careful search in November 1908 for the flower-bud maggot and had failed to find it at that time.

This wild cotton is in a thicket, which is composed of a great variety of plant species, and clumps of wild cotton bushes are growing at intervals by the roadside, and in the wild land on several acres. It is evidently either an indigenous species, or an escape from cultivation in the old cotton-growing days, which has entirely reverted to an ancestral type or has become greatly degenerated. This may be taken as the most typical growth of wild cotton at Antigua. There has been no cultivation of cotton nearer than from a mile to a mile and a half since the revival of cotton cultivation in 1903.

The first buds examined on January 9 were from a plant which grew beside the road, at a distance of a few yards from the edge of the thicket. No maggots were found in these buds. The plant had buds, flowers, and developing bolls on it. The next buds examined were from plants growing in the thicket, near the roadside, and surrounded by a great number of woody plants. The first of these buds examined, contained no Cecidomyiid larvae, and this was true of nearly every bud examined at this point. These cotton plants were in bloom and bolls were developing on them. It is remarkable that, in spite of flower-bud maggot attacks, the wild cotton produces a large number of flowers, and ripens the bolls from them. In February and March 1908, when the cultivated cotton was suffering from the most extreme attack, these wild cotton plants were producing flowers and bolls.

Examination of the flowers and buds of several trees and shrubs growing in the thicket near to the attacked cotton failed to reveal the presence of cecid larvae, except in the case of the Privet or Wild Coffee (*Clerodendron aculeatum*) in which a maggot was found. Parasitic Hymenoptera were found on the Privet which seem to be the same as those found on infested cotton. (Nos. 901 and 902.) Examination of Privet from other localities in Antigua showed that the inflorescence of this plant is generally infested by cecid larvae. A large amount of Privet flower clusters were collected from the hedge at the Botanic Station, for the purpose of rearing the adult fly for comparison with the adult of the cotton flower-bud maggot.

From this material I reared two (or three) species of cecid

flies, one of which I believe to be *Contarinia gossypii* (see p. 18 and p. 25 of this paper).

I visited Gamble's cotton at McKinnon's on January 13. This (Spring Piece) was planted in September, the field extending from low-lying rich land up to thin land on the hillside. At the bottom, near the canes, the growth was strong and vigorous, while higher on the hillside it was smaller and less vigorous. The earliest bolls were just beginning to open; the youngest were probably about three weeks old, that is, speaking generally, no bolls had been formed for about three weeks, although the plants were making efforts to develop flowers. No very small buds had dropped during the previous two or three days, or at least, they were not to be seen on the ground. Many larger buds, which had nearly opened, were infested. My notes on this field at the time of this first visit were: 'The attack seems to have stopped; the young affected buds have dropped, the older, more resistant ones are still hanging on.'

Parasitic Hymenoptera and the flower-visiting flies were much less abundant than last year.

On January 19, I visited Spring Piece again and found that the attack seemed to be on the increase. A patch of wild cotton growing near the east side of the field was thoroughly infested. This might be the source of the attack for this portion of the estate, but other fields at some distance were about as badly infested. I found no Privet near.

Many young buds were attacked and falling, but there were still many half-grown or more advanced, which gave the appearance, at first sight, of a fair number of flowers.

The greatest number of buds seemed to be escaping attack at the lowest side of this field, near the spring. The attack was more severe near the upper east side of the lower part of the field. This is the field in which the experiments described on page are in progress.

On January 28, the cotton at McKinnon's was seen to have been badly attacked by the cotton worm, except at the bottom where the attack was slighter, and where also the flower-bud maggot attack was still bad. Many young bolls were dropping also. These bolls may have been developed from flower buds attacked by the flower-bud maggot, but not injured sufficiently to cause the dropping of the bud. The injury, however, might have been severe enough to prevent fertilization, and thus the development of the boll would be prevented. One plant had thirty-one affected buds and half-opened flowers. Not many small buds on the ground, a good number of bolls, half to one-third grown, had dropped also.

The wild cotton at Judges was visited on January 28 also. There were very few flowers, and a small number of infested buds. The most abundant plants in the thicket were the tamarind (*Tamarindus indica*), the wild tamarind (*Leucaena glauca*), the balsam (*Croton balsamifer*), and the Privet.

The flowers and flower-buds of the following plants were examined for the presence of flower-bud maggot:—

Botanic Station, January 13.

Gardenia	*Tecoma capensis*
Balsam	*Canna*
Calotropis	*Casuarina*
Hibiscus	*Russelia*
Ipomoea	*Alamanda*
Thunbergia (White)	*Caesalpinia*
„ (Blue)	*Bougainvillea*
Begonia (White)	*Parthenium*
Cosmos	*Abutelon*
Antigonon	*Clerodendron aculeatum*
Plumbago	

Botanic Station, January 18.

Cardiospermum	*Crotalaria*
Pithecolobium Unguis-cati	*Clitoria*
Gliricidia	*Solanum*

Botanic Station, January 20.

Mimosa	*Ixora*
Rondeletia	*Tecoma stans*
Lantana	*Brunfelsia*
Jasmine	*Jatropha*
Cardiospermum	*Dracaena*
Vinca	*Portulacca*
Saraca indica	*Sonchus*
Tradescantia	*Pithecolobium*
Lawsonia	*Unguis-cati*

Judges, January 28.

Lantana	*Solanum bahamense*
Croton balsamifer	

Botanic Station, January 28.

Mimosa	Ground Cherry
Solanum	*Bryophyllum*
Salvia	Broomweed
Jatropha	Wild Ochro
Desmodium	Anise
Wild Daisy	*Chrysanthemum* sp.
	23 not named.

In these examinations a cecid larva has been several times found in the flowers of Bread-and-cheese (*Pithecolobium Unguis-cati*), but I have not yet reared the adult.

At Archibald's, Caravonica cotton was attacked in the same way as the Sea Island and ordinary native cottons. The Caravonica was growing in a field directly adjoining the Sea Island, and was apparently quite as seriously attacked as the latter.

At Blubber Valley, there has been but little cotton planted. The flower-bud maggot has not been abundant. As the first

picking of cotton is finished, all this cotton land will be put into canes. At Orange Valley, buds were seen with the apearance of being attacked, but no maggots could be found. At Cade's Bay the situation was much the same apparently, only a few buds and flowers had been lost. Maggots were discovered in these fields however.

During my stay in Antigua, the Curator, Montserrat, forwarded specimens of cotton flower-buds infested by cecid maggots. The occurrence of the flower-bud maggot in Montserrat was reported in 1908, but the insects were not submitted for examination. In the case of the material submitted in January 1909, there does not seem to be any doubt that it is the same as the Antigua insect. At least, it attacks cotton in the same way: produces the same results, i.e., the loss of the flower-buds, and the maggots are the same in appearance.

EXPERIMENTS.

In addition to the experiments already mentioned, two series were carried out at Yepton's and Blubber Valley, by Mr. Jackson after my departure from Antigua, 1908.

These consisted of five plots on each of these estates, of $\frac{1}{10}$ acre each. which received per plot:

Lime	200 lb.	
Nitrate of soda	21 „	
Vi-phosphate	21 „	
Salt	10 „	
Vaporite	48 „	2 applications of 21 lb. each.

The 1909 experiments are given in my report (see pp. 16-17).

LABORATORY NOTES, 1909.

Privet (*Clerodendron aculeatum*) collected on January 15 at Botanic Station, placed in rearing jars—wide-mouthed glass jars—with about 2 inches of mould at the bottom. on which the mass of flower-buds, flowers, etc., were placed. The first cecid flies were obtained on January 22, and others on the 23rd, 25th, 26th, and 27th.

The flies taken from these jars on January 22 and 23 seem to be of two species, and they have been given the catalogue numbers 932 and 933.

On January 25, 26, and 27 the flies taken from these jars included, in addition to 932 and 933, the male of what appeared to be another species 934, and *C. gossypii* (895). This species, *C. gossypii*, from wild cotton, took fifteen days, from January 9 to 24, from the date of collection to the emergence of the first adult, while from the Privet the interval was only eleven days.

The rearing of *C. gossypii* from Privet would indicate that *Clerodendron aculeatum* is a host plant for this insect as well as for other species of related insects, and it is a likely source from which cultivated cotton is infected. It seems probable, that by using a plant that is in bloom at most times of the year,

C. gossypii manages to keep going throughout the year. Otherwise it might be obliged to hibernate for periods longer than its whole life cycle. It may be that this is possible for it.

The plants on which this insect lives also must be more generally distributed and more abundant than the wild cotton in Antigua. The flower-bud maggot apparently needs but little distributing each year.

Early in this paper, reference has been made to the rainfall and the wet season of 1907 in regard to the possibility of these conditions influencing the severity of the outbreak of flower-bud maggot. The following table shows the rainfall on a number of estates for six years, 1902-7 :—

AVERAGE YEARLY RAINFALL FROM 1902-7.

	1902	1903	1904	1905	1906	1907	Average.
Blubber Valley	60·14	60·45	46·45	42·01	71·72	45·79	54·42
Collins ...	56·83	32·86	35·74	29·84	...	32·65	37·58
Thibou's ...	...	33·56	35·38	26·21	41·22	35·61	34·39
Wetherill's ...	51·71	48·29	38·57	29 31	47·98	36 84	42·11
Colebrook ...	...	...	...	..	...	49·21	...
Gamble's ...	50·05	42·69	29·53	28·06	56·18	43·59	41·68
Orange Valley	...	...	36·78	35·43	61·62	52·18	46·5
Yepton's ...	50·61	51·71	31·63	26·75	47·56	35·48	40·62

The Antigua annual rainfall, with a note by Dr. Watts, is also given, showing that 1907, though not a wet year, gave the effect of a wet year :—

ANTIGUA AVERAGE RAINFALL.

	Stations.	Average.
1902	71	58 80
1903	68	43·68
1904	70	37·01
1905	68	31·40
1906	66	53·93
1907	70	43·45

'The average rainfall for thirty-four years from 1874 to 1907 inclusive, was 45 75, so that the rainfall for 1907 was 2 30 inches below the average. The distribution of the rainfall has been such as to give the effect of a wet year. This is in striking contrast with the previous year, when with a total rainfall above the average, the distribution was such as to produce the effect of a drought.'

Mr. Tempany furnished the writer with tables giving rainfall, minimum temperatures, dew points, etc., over a limited area, with a view to showing the relationships between dampness, rainfall, etc., and the abundance of the flower-bud maggot, and with notes which are summarized thus :—

The attack of 1907-8 began apparently in November 1907, about six weeks after the heavy rainfall in each October, which made the beginning of a long damp period. During December 1907 and January 1908 the dampness continued and the flower-bud maggot also continued and reached its greatest degree of abundance. In February, the damp conditions gave way to drier, and the flower-bud maggot attacks began to be less. In September 1906, there was a very heavy rainfall in Antigua, but in spite of this the flower-bud maggot did not become sufficiently severe in its attacks to be recognized, although it was in all probability present. The yield of cotton per acre was better during the crop of 1906-7 than in the following year.

It will be seen from the notes given above that the average rainfall for Antigua for the thirty-four years, 1874 to 1907, was 45·75 and the rainfall for the years 1902-7 ranged from 31·40 to 58 80. The abundance of the flower-bud maggot seems to be in relation to the humidity and dampness but not to the actual rainfall. As already mentioned (see p. 5), the first recognized outbreak of the flower-bud maggot must have taken its start on a large scale from the exceedingly damp conditions

prevailing in Antigua during September and October 1907, when, although there was little rainfall, there was at the same time but little sun. The table shows that at Blubber Valley the rainfall for 1907 was 45·79, the lowest, except for 1905, of the six years given.

The influence of the dampness and of the chill nights was noticed again in the second outbreak, which probably reached serious proportions about the middle of December. During January 1909 planters noticed improvement in the field conditions with a few warm dry days and an equally sudden change for the worse following rains with chill nights. The conditions which favour the rapid increase of the flowe-rbud maggot at Antigua in certain seasons are apparently somewhat the same as those which some years ago, when malarial fevers were much worse than now, led the inhabitants always to expect serious outbreaks of fever at the end of the year.

The dry, hot days of March 1908 were accompanied by a rapid decrease of the attack of the flower bud maggot, and in 1909, an improvement had been made during January and February.

SUMMARY.

The flower-bud maggot is a minute insect, the larvae of a very small fly (*Contarinia gossypii*).

The flower buds of cotton are attacked, the eggs being deposited in the bud by the fly. The maggot causes so much injury to the bud that it usually falls while quite young.

Attacked and infested buds usually flare their bracts. This seems to be always true when very young buds are attacked, although injury from other causes results in the flaring of the bracts : older buds do not always flare when attacked.

Infestation has been known so severe that no bolls were formed for several weeks at a time when the greatest development of bolls should have been going on.

The flower-bud maggot has caused serious loss to cotton growers in Antigua in 1907-8 and 1908-9. It has also appeared in Montserrat in 1909.

The flower-bud maggot is directly influenced by weather conditions. Damp weather, and especially damp weather accompanied by cool nights, seems to be particularly favourable to the flower-bud maggot, while heavy rains do not appear to have much influence in this way.

Dry weather with hot suns seems to have a great influence in reducing the severity of the attack.

No suitable remedies have been discovered so far. Hand picking of infested buds, the use of Vaporite, and the destruction of wild cotton and Privet, are all suggested as worthy of trial. Cultural methods which keep the surface soil as dry as possible, and free from weeds should act as a check on the pest.

Probably, in favourable seasons, when cotton can be planted early, the flower-bud maggot attacks will be much less severe,

THE COMPOSITION OF ANTIGUA AND ST. KITT'S MOLASSES.

BY

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AND

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During recent years the importance of the position occupied by molasses in the muscovado sugar industry has been more and more clearly recognized, and with the changes taking place in methods of sugar production, the demand for muscovado molasses of good quality has increased, and has assumed a fairly stable position.

Of British West Indian molasses, that produced in Barbados and Antigua is at present in good demand, but the demand is not so ready for that produced in St. Kitt's. It is the object of the present enquiry to see if any facts can be found which account for this difference.

For this purpose it was decided to procure a number of representative samples of muscovado molasses from estates in each Presidency, and to institute a careful analytical comparison between them.

The obtaining of really representative samples of muscovado molasses is by no means an easy task, since the average conditions under which they are stored render them peculiarly liable to infection by micro-organisms, which may cause considerable changes in composition. On this account, therefore, it appeared to us that the best method of procuring samples would be direct from the massecuite itself, before the process of curing had been commenced, and to extract the molasses from that.

Accordingly, samples of massecuite were obtained from the coolers of six representative muscovado estates, three in Antigua and three in St. Kitt's. These samples were cured in a laboratory hand-centrifugal, and the spun-out molasses preserved in glass-stoppered bottles. Each sample was sterilized in the containing jar as soon as it had been prepared, by heating in the steam oven at 100 C. for one hour, the object of this being to preserve the samples from alteration through bacterial infection.

The sterilized samples were allowed to stand for some seven weeks before being analysed in order to permit of any suspended fine-grained sugar settling out. By this means, samples of molasses were obtained in an absolutely fresh condition, in which they could be regarded as representative and unaltered products.

METHODS OF ANALYSIS.

The ordinary technical methods of analysis are, by themselves, of very little use as a guide to the true composition of

molasses. The method of analysis most usually employed is that of the simple direct polarization of a normal weight of molasses, which is taken as an approximate estimation of the sucrose content.

The results obtained in this way can, at the best, be only of the most approximate description, by reason of the large errors incident on the process; namely, (1) the presence of considerable amounts of optically active sugars other than sucrose, which by their different optical activity render the result erroneous as a measure of the sucrose present, and (2) the effect of the volume of the lead precipitate when a solution of basic lead acetate is used as the clarifying reagent. In the case of dark-coloured, low-grade products, it happens frequently, that considerable quantities of the reagent have to be used to effect clarification, and relatively very large errors are liable to be introduced thereby.

In a similar way, if the total solids are deduced directly from the specific gravity of a 10-per cent. solution, errors are liable to arise owing to the effect of the presence of soluble ash on the solution density.

In an analysis of molasses which attempts to arrive at an approach to accuracy, it is necessary to correct for these various errors. The optical error in the determination is removed by the employment of the Clerget inversion process. The lead volume error is obviated by the employment of the dry basic lead acetate defecation method. For a full discussion of the effect of this error, and the methods of remedying it, readers are referred to papers by ourselves which have already appeared in the *West Indian Bulletin.**

The effect of the soluble ash on the determination of the total solids from the specific gravity of a 10-per cent. solution is corrected for by the employment of the correction formula devised by J. Heron.**

In the determinations, given below, the sucrose and total solids were determined by the methods already quoted—the ash by sulphation and burning, after evaporation, of a measured quantity of a 10-per cent. solution. and the glucose by titration of a 10-per cent. solution against Fehling's solution.

The water is obtained by substracting the sum of the total solids from 100.

In addition to the above, the refractive indices of the samples were determined by means of the Abbé refractometer,

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*The Polarimetric Determination of Sucrose. Parts I, IV, and VII, *West Indian Bulletin*, Vol. VI, p. 52, and Vol. IX, pp. 117 and 123.

**This is as follows :—

Deduct $\frac{10}{20}$x·8 of the sulphated ash from the specific gravity of a 10-per cent. solution, water being reckoned as 1,000 ; the resulting figure gives the solution density of the organic total solids exclusive of the ash.

As illustrating the first of these corrections, the following table gives water contents of the six samples of molasses examined, as calculated di ect from the specific gravity of a 10-per cent. solution with and without the correction for ash.

	A.	B.	C.	D.	E.	F.
Water per cent. (Heron's correction applied)	25·4	30·0	24·8	24·7	22 9	27·0
„ „ „ „ „ not „	22·7	26·2	23·0	21·4	20·4	23·0

and the water per cent. calculated therefrom in accordance with the recent results of Main and Prinsen Geerligs. In two instances, also, as a further check, the water was determined by direct drying of a measured quantity of a 10-per cent. solution on a coil of filter paper at 100 C., in a current of dry air and under reduced pressure. As the results obtained in this way are of only special scientific interest, they are briefly discussed in the addendum to this paper.

RESULTS OF ANALYSES.

Working on the above lines the following results were obtained from the six samples in question. Of these samples A, B, and C are Antigua molasses; D, E, and F are St. Kitt's molasses.

Constituent.	Antigua.			St. Kitt's.		
	A.	B.	C.	D.	E.	F.
Sucrose	55·7	51·6	56·2	49·8	46·9	50·7
Glucose	10·3	8·1	11·4	14·4	24·2	6·8
Non-sugar	5·4	5·3	4·8	8·2	2·7	10·4
Ash	3·2	4·2	2·8	2·9	8·1	5·0
Water	25·4	30·8	24·8	24·7	22·0	27·1
Total	100·0	100·0	100·0	100·0	100·0	100·0
Specific gravity, 10 per cent. solution...	1·0263	1·0250	1·0267	1·0268	1·0272	1·0267
Refractive index at 28° C.	1·4727	1·4728	1·4747	1·4764	1·4812	1·4735
Percentage of water from Refractive index	26·4	26·35	25·6	24·85	22·9	26·1
Percentage of water by direct determination	27·8	30·6	..	...		...

Comparisons were made of a number of Antigua and St. Kitt's samples, including the above, on external characters of taste, smell, colour, and appearance. As the outcome of

examination it was found that, whereas the Antigua samples, in the majority of instances, were possessed of a pleasant fruity smell, and in flavour were sweet, fruity, and palatable, the St. Kitt's samples were generally rough and harsh.

On comparing the analyses of the Antigua and the St. Kitt's products, one is immediately struck by the relatively small amount of sucrose present in the St. Kitt's molasses when compared with that of Antigua. Taking the average of the three samples from each Presidency, this difference amounts to 5·3 per cent. A difference of this description would be quite sufficient to account for the different demand existing for the two products.

Comparing the other constituent, no very marked or regular differences between the two lots of samples appear. The tendency of the glucose and non-sugar is to be somewhat higher in the St. Kitt's samples than in those from Antigua, which points to the greater exhaustion of the molasses in the case of the former Presidency.

The water and ash of both sets of samples show no marked differences.

As the result of these analyses, we are brought to the conclusion that the differences existing in demand for the molasses of St. Kitt's and Antigua are due to the fact that the St. Kitt's molasses contain less sucrose than do those of Antigua, pointing to greater exhaustion of the molasses in the process of manufacture.

This result, we think, cannot be attributed to differences existing in the process of manufacture of muscovado sugar as practised in Antigua and St. Kitt's, but is rather to be put down to differences in the composition of the cane grown in the two Presidencies, owing to differences in soil and climate.

The difference must be attributed to the Antigua cane containing a larger amount of 'gum' than the St. Kitt's cane, presumably in consequence of the conditions under which it is grown. This has the effect of rendering the sugar made from it less free-draining and probably, at the same time, increasing the actual amount of molasses formed, and also increasing the sucrose content of it.

It may further be pointed out that the average difference of 5·3 per cent. between the sucrose contents of St. Kitt's and Antigua molasses may represent a considerably higher recovery of sugar in the case of St. Kitt's than the above actual difference in the per cent. of sucrose in the molasses, since in all probability not only does the molasses contain less sugar, but also there is less molasses actually formed.

In the event of its being desired to establish a trade in molasses from St. Kitt's, it seems probable that an article of improved quality might be produced by boiling to a lower concentration in the process of sugar-making.

It is well known that St. Kitt's sugars cure more readily than those of Antigua, owing, presumably, to the less gummy nature of the juice from canes grown in the former Presidency. In consequence, St. Kitt's muscovado sugars generally test higher than those manufactured in Antigua.

It may further be pointed out that, whereas it is a common thing for gum to be found accumulated on the surface of massecuites in the coolers in Antigua—and, it may be added, also in Barbados—we believe it rarely occurs in sugar-houses in St. Kitt's.

In this connexion it may be mentioned that Antigua sugar soils, in common with those of Barbados, contain considerably larger proportions of clay than those of St. Kitt's, the typical St. Kitt's sugar soil being deep, sandy, well drained, and mellow.

We regard it as possible that this difference in character between the soils of these two islands may account for the differences observed in the character of the molasses produced in each.

A further fact, which may possibly have some bearing on the question, though at present its influence is not obvious, is that both in Antigua and Barbados there are large areas of soils derived from limestone, while in St. Kitt's the soils contain remarkably little lime.

To sum up, Antigua and St. Kitt's molasses differ in the demand that exists for them: this difference is accounted for by differences in composition. St. Kitt's molasses contains less sucrose than Antigua molasses, the recovery of sugar appearing to be better.

In conclusion, we would acknowledge assistance received from Mr. H. L. Thomas in the performance of some of the analytical work herein referred to.

ADDENDUM.

The importance of the refractometer as a possible aid to sugar-house control is at the present time attracting considerable attention. This point has been sufficiently demonstrated by the work of Main, Tolman and Smith, von Lippman, and especially that of Prinsen Geerligs. On this account, the results of the determination of the water contents of the above samples by the refractometer are given for comparison with the water contents as calculated from the specific gravity of a 10-per cent. solution, using Heron's correction for ash, and in two instances with the moisture by direct determination.

It will be seen that the results agree fairly closely, the agreement being, on the whole, better in the case of the St. Kitt's samples than in the case of those of Antigua. In only one instance is there any wide divergence between the results obtained by the two methods, namely, that of sample B, where a difference of 4·1 per cent. exists between the refractometer results, and those found by direct dryings and by calculations.

It was thought that differences in the composition of the ash might account for the differences observed, and therefore, determinations of the lime, potash, and soda were carried out

on sample B, and on sample F, from St. Kitt's, for the sake of comparison; also of lime only from sample E.

The results are as follows:—

			B.	E.	F.
Lime	...	(CaO) per cent.	·58	·51	·55
Soda	...	(Na_2O) „ „	·35	...	·77
Potash	...	(K_2O) „ „	·94	...	·92

It will be seen that, although differences exist between the compositions of the different ashes, they are insufficient to account for the observed discrepancy in the case of sample B, and some other cause must be sought.

The possible occurrence of such discrepancies must necessarily limit the usefulness of the refractometer in this direction.

THE PASSING OF THE BOURBON CANE IN ANTIGUA.

BY H. A. TEMPANY, B.Sc. (LOND.), F.I.C., F.C.S.

This paper has been prepared from notes accumulated in the Government Laboratory for the Leeward Islands during the past twenty years by, and under the direction of, Dr. Watts, the writer having worked up the present account from the records. The fact that these notes were only made as part of the routine record of the work accomplished, and not with any reference to use in connexion with a paper such as this, makes them even more significant, and perhaps adds to their value for the purpose of drawing deductions, although the story is not so completely linked up as might have been the case, if the present argument had been borne in mind during those earlier days.

Prior to 1895-6, the Bourbon was practically the only variety of sugar-cane cultivated in Antigua. In that year, and in several previous years, attacks of the rind fungus (*Trichosphaeria sacchari*) had assumed such serious proportions that the cultivation of this cane was attended with considerable loss, and the sugar industry as a whole was in a very hazardous position.

The Bourbon cane had been grown in the West Indies for a period of something like 130 years, and up to this time had been cultivated far in excess of any other variety. At the present time, the Bourbon cane is grown on a fairly large scale in Demerara, Trinidad, and St. Lucia. In Antigua, St. Kitt's, and Barbados, however, it has been almost entirely abandoned. The rapid spread of the rind fungus and the greatly increased susceptibility of the Bourbon cane to this disease form one of the most remarkable stories in the whole history of West Indian agriculture. It is hoped that

the data presented in this paper may help to clear up the mystery which has for the past ten years enveloped the rapid passing of the Bourbon cane, and the adoption, in its stead, of seedling and other varieties.

Even at the present time the Bourbon cane is held in high esteem by many of the older planters in Antigua. Many of them state that they would resume the cultivation of this variety if they had any guarantee of immunity to disease. It is true that the Bourbon cane possesses many valuable points, and its reputation as a cane particularly suited to conditions in Antigua is, on the whole, well founded. The records summarized herewith, give evidence of this. It is also probably true, however, that its valuable qualities seem greater now, after a lapse of years, and in the absence of exact records which would serve for confirmation, than the facts of the case actually warrant.

Messrs. Deerr and Eckart recently published a paper on the nomenclature of cane varieties, in which it was shown that the Bourbon cane probably took its origin from the island of Otaheite, and from that place was introduced to the various cane-growing areas of the world.

The history of the introduction of the cane to the West Indies appears to have been as follows:—

(*a*) It was introduced early to the island of Bourbon, whence it was transported to Martinique and other French possessions in the West Indies in the middle of the 18th century.

(*b*) It was introduced into Antigua direct from Otaheite by Sir John Palfrey in the 18th century.

(*c*) It was introduced into Jamaica from Otaheite by Captain Bligh in 1798.

Messrs. Deerr and Eckart suggest that the Bourbon is not an absolutely pure strain, but represents a mixture of two Otaheite canes, one of which has been designated in Hawaii as the Lahaina, while the other is known as the Cuban. If this is so, it is moderately safe to assume that they have become mixed to a very large extent at the present time.

A list of the probable synonyms for the cane is as follows: Bourbon, Otaheite, Lahaina, Colony, Cuban, Keni Keni, Portier, Louzier, Yellow, China II, and Bamboo II.

In appearance, the cane is typically a stout, handsome, long-jointed, green to yellow cane with a tendency to sunburn where exposed. It is a shallow-rooted cane with a tendency to trail.

A consideration of the character of the cane crop in Antigua at the time when the Bourbon cane was at its prime will be of special interest in this connexion. As already stated, the Bourbon cane was practically the only variety cultivated in Antigua up to 1895-6. The critical situation of the sugar industry on account of the attacks of the rind fungus led to the abandonment of the Bourbon cane and the substitution of other varieties, of which the White Transparent became the

one most widely grown. In 1889, Mr. (now Dr.) Francis Watts was appointed Government Chemist for the Presidency, and from that time to 1898 he accumulated a large amount of information in regard to the sugar industry of the island. Previous to that period, however, no reliable data were recorded in regard to the yield of the cane or the composition of the juice, the only figures relating to the early sugar industry being of the vaguest kind.

It will readily be seen that for the purpose of this paper, no information previous to 1889 would be of any value. The following account of the effect of the attacks of rind fungus on the Bourbon cane is taken from various departmental publications :—

> In the earlier stages an infected field frequently presents a normal healthy appearance until a comparatively late stage of growth. The first sign of the disease shewn. is that the leaves of the canes have a tendency to dry up and turn yellow, the discoloration spreading from the margins of the leaves till the whole top is dead and dry.
>
> The stem then begins to be affected, becoming discoloured in patches in the internodes. These patches are brownish in colour and somewhat suken. If the stem is cut into, the underlying tissues will be found to be discoloured, red and brown.
>
> Canes such as these break off easily in the wind or at any slight shock.
>
> At a somewhat later stage black pustules appear on the rind of the cane which subsequently burst, and from them small hair-like growths are protruded, consisting of chains of spores of the fungus causing the disease, loosely cemented together by a mucilaginous substance. These spores, under suitable conditions, are capable of germinating and further developing the disease.
>
> When one of these spores germinates under favourable conditions, a tube is put forth which continues to grow, and forms a ramifying mass of threads or hyphae. In the cane the disease spreads by means of these hyphae, which grow and branch, spreading from cell to cell. It is probable that the hyphae secrete some ferment capable of dissolving a passage through the walls of the cells, the hyphae then passing through and filling the cell cavities.
>
> In the cells the fungus feeds on and destroys the saccharine contents of the juice, the effect being first of all seen in a diminution of the sucrose and a rise in the glucose contents, combined with a corresponding rise in the glucose ratio and fall in the purity.
>
> This is presumably to be attributed to the secretion of invertase by the fungus. Subsequently the parasite appears to feed on the glucose and metabolises it into various other products.

A sample of sterile cane juice was inoculated with *Trichosphaeria* in the Government Laboratory for the Leeward Islands. The changes that had taken place after a lapse of three months are indicated in the following analysis:—

Total solids	18·49	per cent.
Sucrose	0·0	"
Glucose	14·96	"
Non-sugar	3·53	"
Specific gravity	1·0672	"

It is generally held at the present time that the disease is propagated by means of wound infection with spores. At the same time the view has been put forward that infection by means of the planting of diseased material may account for the spread of the disease.

In this connexion the following passage taken from a report on the Sugar-cane Experiments conducted at Skerrett's, Antigua, by Messrs. Watts and Shepherd in 1896,* is of interest and importance:—

'It would appear as though the disease attacked the canes by infection through the agency of the soil rather than by aerial infection; or that the prevalence of disease was due to the unconscious use for planting of tops which contained rind fungus. There does not appear to be any relationship between he kind of manure or fertilizer and the prevalence of disease.

'In connexion with the spread of rind fungus by means of infected tops, the remarks of Mr. Massee in his paper on this disease, (*Annals of Botany*, Vol. VII. No. XXVIII. December 1893, p. 519,) are of great importance. He writes: "The external evidence in the form of " 'fruit' " of the parasite is confined to the basal half of the cane, and the very delicate vegetative hyphae are difficult to observe in the tissues. Nevertheless, when internal portions of a diseased cane, taken from near the apex are placed in a nutrient solution, ... the rapid growth of hyphae and the eventual formation of macroconidia prove the presence of hyphae throughout the length of the cane. *By this method the presence of the parasite was demonstrated near the apex of every cane sent for examination.*" '

'The italics are ours.

'With the very wide spread of the disease and the impossibility of distinguishing healthy from diseased "tops" by inspection, *it is more than* probable that the disease is spread by the use of infected tops. At one time we thought that the vigorous growth of the young plant might be taken as evidence of freedom from rind fungus, but seeing that it is possible for some plants to flourish even while serving as hosts to parasitic fungi (as in the case of wheat attacked by smut, etc.), we have reason to fear that cane plants which are apparently healthy may contain rind fungus, and that the discoloration and rotting of tissues of the cane plant must be regarded as evidence that the disease has reached a secondary stage.'

*Report on Experiment Fields at Skerrett's School, 1896, by F. Watts, F.I.C., and F. R. Shepherd.

There seems reason to believe that this disease existed for many years previous to the disastrous outbreak in the middle and later nineties. It is probable also, that *Trichosphaeria sacchari* has been developed from saprophytic ancestry. This opinion is attributed to Massee, and is quoted by Barber. (Report on Diseases Affecting Cane in Barbados, 1893).

In discussing the character of the Bourbon cane in Antigua previous to the serious attacks of the disease, and the effects of these attacks on the cane, the following points need to be dealt with :—

1. The yield of the Bourbon cane in Antigua.
2. The effect of rind fungus on the yield of cane.
3. The composition of the juice of the Bourbon cane.
4. The effect of the rind fungus on the composition of the juice.
5. The effect of disease on the yield of manufactured sugar.
6. The percentage of juice yielded by the Bourbon cane on milling.
7. The effect of manures on the liability of the cane to disease.

It has already been pointed out that no records previous to 1889 regarding the composition of the cane crop in Antigua are of value in connexion with the present investigation: further, it would easily be realized that it took time to get results from experiments started at this time, so that really no results became available until 1892. A series of manurial experiments had been laid out for the crop of 1891-2 on the Government land at Skerrett's, and some information had been accumulated in regard to the working of a number of estates after the crop of 1890.

I. YIELD OF BOURBON CANE.

The practice of weighing the canes systematically appears to have had its beginning in Antigua with the cane experiments on the Government experimental fields, and the weights so obtained, furnish the first available records of weights per acre yielded by the Bourbon cane, though there may have been previous to this time careful weights of cane from measured areas. The manurial experiments already referred to were carried on and amplified for six years, and these have furnished a considerable amount of information for this period. The mean yield of cane per acre from the whole series of experiments as plants and ratoons, calculated for each year from 1892-7, is given in Table I, together with the number of plots from which each result has been calculated.

TABLE I.

MEANS OF WEIGHTS FROM MANURIAL EXPERIMENTS WITH BOURBON CANES FROM 1892-7.

YEAR.	PLANT CANES.				RATOON CANES.			
	No. of plots.	Sound cane, tons per acre.	Rotten cane, tons per acre.	Percentage of rotten cane on sound cane.	No. of plots.	Sound cane, tons per acre.	Rotten cane, tons per acre.	Percentage of rotten cane on sound cane.
1892	23	24·9	1·56	6·3	...	...	..	...
1893	...	...	...	...	...	...	...	..
1894	21	12·1	1·61	13·3	26	10·1	0·27	2·7
1895	28	7·6	0·79	10·4	26	8·8	1·45	16·5
1896	56	22·3	3·71	16·6	28	11·7	2·54	21·7
1897	52	18·4	3·75	20·1	50	10·7	4·31	40·3

In examining these results it must be borne in mind that the crops of 1894 and 1895 were exceedingly small, owing to the very severe drought that prevailed during these two growing seasons, and moreover, the effects of drought and disease were always severely felt at Skerrett's on account of the poorness of the soil, despite the application of artificial manures.

One result of these experiments was that several estates purchased weighing machines and started the practice of regularly weighing canes from known areas, and consequently, a certain amount of information became available after 1892 as to the yield of cane actually obtained on several estates in the Presidency. Table II gives the weights of these yields per acre from 1892-6, and it appears that the yields did not vary greatly from those obtained more recently.

In 1894-5 there was a very decided drop in the yields. This was due perhaps more to the drought than to the increasing attacks of the disease, although in these years there was a very large proportion of rotten cane in the crop. The weights of rotten cane recorded from experiment plots indicate the serious degree to which these attacks of disease had progressed. The percentage of rotten to sound cane in the manurial experiments has been included in Table I, in the figures from the experiment plots.

TABLE II.

WEIGHTS OF BOURBON CANE.

Estate A.

YEAR.	Description of cane.	Acreage.	Total tons of cane obtained.	Tons of cane per acre.
1892	Plants ..	228	8,020·35	35·17
	1st Ratoons ..	177	3,898·65	22·02
	2nd Ratoons	163	2,503·60	15·35
	Total ...	568	14,422·60	25·39 (mean)
1893	Plants ..	211	4,677·30	22·16
	1st Ratoons ..	228	3,719·15	16·31
	2nd Ratoons	177	1,848·65	10·44
	Total ...	616	10,245·10	16·63 (mean)
1894	Plants ...	199	6,076·90	30·53
	1st Ratoons...	211	4,269·60	20·23
	2nd Ratoons	159	2,486·15	15·63
	3rd Ratoons	10	151·95	15·19
	Total ...	579	12,984·60	22·42 (mean)
1895	Plants ...	207	3,124 75	15·09
	1st Ratoons...	199	2,441·00	12·26
	2nd Ratoons	152	1,303 00	8·51
	3rd Ratoons	13	127·50	9·80
	Total ...	571	6.996·25	12·25 (mean)
1896	Plants ...	206	5,424·20	26·33
	1st Ratoons...	202	4,033·85	19·96
	2nd Ratoons	199	2,892·50	14·53
	3rd Ratoons	52	323·75	6·22
	Total ...	659	12,674·30	19·23 (mean)

TABLE II.—(*Concluded.*)

WEIGHTS OF BOURBON CANE.

Estate B.

YEAR.	Description of cane.	Acreage.	Total tons of cane obtained.	Tons of cane per acre.
1893	Plants ...	203·5	3,757·2	18·0
1894	Plants ..	216·9	3,189·25	14·7

Estate C.

YEAR.	Description of cane.	Acreage.	Total tons of cane obtained.	Tons of cane per acre.
1893	Total ...	157·0	2,663·9	17·0
1894	Plants ...	51·25	908·1	17·70
	1st Ratoons...	52·5	677·9	12·95
	2nd Ratoons	44·0	489·9	11·06
	Total ...	147·75	2,075·9	14·05 (mean)
1895	Plants ..	...	1,625·9	...
1896	Plants ...	23·5	564·4	24·0
	1st & 2nd Ratoons	67·0	1,295·95	19·3
	Total ...	90·5	1,860·35	20·5 (mean)

When the cultivation of the Bourbon cane was given up, the White Transparent took its place to a very large extent. At the present time about 75 per cent. of the area under canes in Antigua is devoted to the cultivation of the White Transparent. The yield per acre of White Transparent, therefore, would give a fair estimate of the yield per acre of Antigua canes.

A very extensive series of experiments has been continuously carried out in Antigua from 1899. The yields obtained in these experiments approximate closely those on estates. Table III gives the average yield of White Transparent per acre both as plants and first ratoons. The experiment plots occur in all parts of the cane-growing area of the island, and in each case the number of plots is given from which the mean results are deduced. From a comparison of this with the preceding table it will be seen that the yield of the Bourbon cane in earlier days did not much exceed that of the White Transparent at the present time, although the Bourbon gave satisfactory yields in good seasons, and on certain soils, such, for example, as the soil of Estate A, Table II, which is a very heavy, non-calcareous clay.

TABLE III.

MEAN WEIGHTS OF WHITE TRANSPARENT CANES OBTAINED ON TEN EXPERIMENT PLOTS FROM 1900-8, IN TONS PER ACRE.

Year.	Plants.		Ratoons.	
	No. of plots.	Cane, tons per acre.	No. of plots.	Cane, tons per acre.
1900	12	20·8	...	...
1901	12	25·6	6	23·0
1902	14	30·6	10	26·7
1903	14	28·8	11	17·1
1904	16	25·3	14	17·1
1905	15	17·3	14	13·6
1906	13	17·6	15	10·9
1907	16	23·3	13	12·1

The experiments carried on at Skerrett's from 1892-7 show a comparison of the yield of the Bourbon cane and other varieties grown under the same conditions. The results from these experiments are given in Table IV, which also shows the percentage of rotten cane of each variety.

It will be seen from this, that the White Transparent gave the best yield ; also that the Bourbon was not the only cane which suffered severely from disease. The Keni Keni and the Lahaina varieties gave a larger percentage of rotten cane than the native Bourbon. It is very significant that these varieties are the same as, or closely related to, the native Bourbon.

TABLE IV.

	Keni Keni.	Rappoe.	Red Ribbon.	Lahania.	White Transparent.	Bourbon.	Norman.	Chigaca.
1893.								
Plant canes, tons per acre ...	22·8	19·3	19·3	20·4	17·1	17·7	26·1	15·5
1894.								
Plant canes, tons per acre	16·5	13·0	15·5	10·1	20·0	13·7	12·2	17·2
Ratoon canes, tons per acre	15·1	13·1	14·4	13·9	17·7	10·7	6·7	10·1
1895								
Plant canes :								
Tons of sound cane per acre ...	8·0	13·2	...	8·4	13·7	8·0	11·1	9·6
Rotten cane, pounds per acre ...	405	243	891	...	378	540	972	378
Rotten cane, % on sound cane ...	2·2	0·8	...	...	0·8	3·0	3·9	1·7
Ratoon canes :								
Tons of sound cane per acre ...	died	8·4	16·0	3·2	16·1	10·4	5·0	7·1
Rotten cane, pounds per acre ...	...	...	...	...	...	4,140	...	...
Rotten cane, % on sound cane ...	...	...	...	...	...	17·7	...	...

TABLE IV.—(*Concluded.*)

	Keni Keni.	Rappoe.	Red Ribbon.	Lahania.	White Transparent.	Bourbon.	Norman.	Chigaca.
1896.								
Plant canes :								
Tons of sound cane per acre ...	16·1	29·5	26·3	14·7	34·1	23·0	22·8	24·1
Rotten cane, pounds per acre ...	6,390	2,490	690	6,450	2,160	7,080	2,790	1,083
Rotten cane, % on sound cane ...	17·8	3·8	1·2	19·5	2·1	13·7	5·5	2·0
Ratoon canes :								
Tons of sound cane per acre ...	4·8	14·9	15·7	10·1	19·2	14·3	8·9	12·6
Rotten cane, pounds per acre ...	1,890	864	837	1,674	..	7,020	1,221	351
Rotten cane, % on sound cane ...	17·6	2·6	2·4	7·4	...	22·0	6·1	1·2
1897.								
Plant canes :								
Tons of sound cane per acre ...	5·9	22·5	20·2	4·7	27·6	18·8	27·3	14·7
Rotten cane, pounds per acre ...	10,248	6,384	4,224	9,936	6,072	7,310	6,000	6,408
Rotten cane, % on sound cane ...	76·9	12·6	9·3	93·5	9·8	17·4	9·8	19·4
Ratoon canes :								
Tons of sound cane per acre ...	4·2	19·3	15·6	6·8	18·2	12·4	14·2	13·2
Rotten cane, pounds per acre ...	930	1,680	1,440	2,850	3,780	14,100	3,690	1,890
Rotten cane, % on sound cane ...	10·0	3·9	4·1	18·2	9·4	50·7	11·6	6·4

COMPOSITION OF THE JUICE OF THE BOURBON CANE.

The juice for the entire crop of a number of estates from 1891-7 was systematically sampled and analysed throughout the entire crop for each year. The collected results of these analyses furnish the true average composition of the juice of these estates for the years given, and these results may be regarded as a fairly accurate index to the average composition of the cane juice in Antigua during that period. During 1893 the juice from eleven, and in 1891, that from ten estates was thus sampled and analysed. The results obtained in this work, which are summarized in Table V. show clearly the approximate comparison of the juice of the Bourbon cane, and also the effect of the disease on the juice.

TABLE V.

COMPOSITION OF JUICE.

	Total solids, lb. per gal.	Sucrose. lb. per gal.	Glucose lb. per gal.	Non-sugar.	Glucose ratio.	Purity.	Specific gravity at 84° F.
Estate A.							
1892	..	1·83	..	..	...	.	.
1893	..	1·72		..	...	..	...
1894	2·00	1.72	0·10	0·14	6·02	85·91	1·074
1895	1·89	1·63	0·12	0·14	7·49	86·15	1·070
1896	1·87	1·57	0·15	0·13	9·52	85·15	1·068
1897	1·84	1·55	0·13	0·16	8·57	84·29	1·068
1898	2·05	1·76	0·08	0·21	4·67	85·76	1·076
1901	2·01	1·71	0·09	0·21	5·45	85·08	...
1902	1·82	1·50	0·14	0·17	9·43	82·79	1·066
1903	2·01	1·77	0·09	0·15	4·90	88·20	1·073
Estate B.							
1891	...	1·95	0·07	..	3·70	...	..
1892	...	1·98	0·08	...	4·00	...	...
1893	...	1·96	0·06	...	2·85	...	...
1894	2·17	1·93	0·06	0·18	3·36	88·77	1·080
1895	1·97	1·68	0·09	0·20	5·40	85·20	1·073
1901	2·21	1·96	0·05	0·20	2·44	88 90	...
1902	2·05	1·81	0·09	0·15	4·82	88·60	1·066
1903	2·22	2·00	0.06	0·17	2·86	90·00	1·081
1904	2·25	2·07	0 04	0·14	2·10	92·00	1·083
Estate C.							
1891	...	1·96	0·05	..	2·50	...	...
1892	...	1·92	0·10	..	4·90	...	..
1893	1·99	.	0 06		3·21	..	...
1894	2·24	1·93	0·08	0·23	4·17	86·31	1·083
1895	2·02	1·70	0·14	0·18	8·06	84·38	1·075
1896	1·84	1·56	0·10	0·18	7·03	84·74	1·068

TABLE V.—(*Concluded.*)

COMPOSITION OF JUICE.

	Total solids, lb. per gal.	Sucrose. lb. per gal.	Glucose lb. per gal.	Non-sugar.	Glucose ratio.	Purity.	Specific gravity at 84°F.
Estate D.							
1893	...	1·84	0·09	...	4·83	...	...
1894	2·13	1·83	0·08	0·23	4·28	85·77	1·079
1895	2·06	1·73	0·08	0·25	4·55	85·80	1·075
1896	1·84	1·51	0·11	0·23	7·14	81·90	1·068
1897	2·00	1·66	0·12	0·21	7·37	83·28	1·074
Estate E.							
1893	...	1·87	0·08	...	4·16	...	...
1894	2·02	1·73	0·09	0·20	5·45	85·63	1·074
Estate F.							
1893	..	1·96	0·07	...	3·49	...	...
1894	2·13	1·89	0·08	0·16	4·43	88·54	1·079
Estate G.							
1893	...	1·87	0·08		4·40	..	...
1894	2·05	1·74	0·09	0·21	5·35	87·04	1·076
Estate H.							
1893	...	1·89	0·07	...	3·79	..	...
1894	2·25	2·01	0·07	0·18	3·43	89·17	1·083
Estate I.							
1893	...	1·92	0·08	..	4·07	...	...
1894	2·11	1·80	0·09	0·22	5·15	85·26	1·078
Estate J.							
1893	...	1·94	0·09	...	4·75	...	...
1894	2·20	1·91	0·07	0·20	4·50	86·90	1·081
Estate K.							
1891	...	1·99	0·06	...	3·00	...	...
1892	...	1·87	0·12	...	6·25	..	...
1893	...	1·84	0·07	...	3·99	...	...
Estate L.							
1901	2·20	1·93	0·06	0·21	3·29	87·80	...
1902	1·94	1·67	0·10	0·17	6·16	86·00	1·061
1903	2·24	1·99	0·07	0·19	3·27	88·80	1·082
1904	2·18	1·96	0·06	0·16	3·20	89·60	1·080
1905	2·17	1·92	0·07	0·18	3·40	88·60	1·080
1906	2·16	1·90	0·07	0·19	3·70	88·00	1·079

It would appear from the investigations which have been made, that under normal conditions the juice of the Bourbon cane contained about 1·9 lb. of sucrose per gallon, and that the glucose ratio was from 2·5 to 3·0. This would indicate that even under normal conditions when the Bourbon was at its best, the juice was not as rich as the juice of some of the canes grown at the present time.

Table V shows the composition of the juice of the Bourbon during those years when the attacks of disease were so extremely severe, and in the cases of estates A, B, and L, the results of analyses in later years when the Bourbon had almost passed out of cultivation.

The enormous increase in the attacks of the disease in 1895-6 was followed by a considerable diminution of the sucrose content combined with the rise in the glucose content and corresponding rise of the glucose ratio. Examination of the figures shows that the effects of the disease did not become marked until 1894; hence prior to that time the figures obtained are probably a close approximation to those normally obtained during many years previous.

From 1894 onwards, the deterioration of the cane proceeded at a rapid rate, and by 1896 the quality of the juice had become very poor, as a result of the ravages of the fungus.

The deterioration of the quality of the juice was severely felt under muscovado boiling-house conditions. Sugar-making became very difficult, and many estates were compelled to convert the bulk of their crops into syrup, because the juice would not make muscovado sugar. It is very likely that this poorness of the juice and the consequent difficulty of manufacturing muscovado formed the principal reason for the abandonment of the Bourbon cane after 1896.

In Table VI. figures are collected which show the number of tons of canes and gallons of juice required to make a ton of sugar, from the year 1893 to 1895 on three estates. This further shows the effects of the disease on the quality of the juice, and consequently, on the conditions in the boiling house where muscovado sugar was made.

TABLE VI.

	Tons of cane required to make 1 ton muscovado sugar.			Gallons of juice required to make 1 ton muscovado sugar.		
	A.	B.	C.	A.	B.	C.
1893	13·9	12·3	11·1	1,610	1,378	1,411
1894	14·0	13·4	13·0	1,662	1,460	1,411
1895	16·9	...	16·0	1,833	...	1,734
1896	14·5	...	16·0	1,733	...	1,747

Table VII contains a statement of the yields of sugar per acre given by the varieties of canes grown on the experiment plots during the years 1892-7 in comparison with the Bourbon. The results given in this table are significant, and illustrate the falling off in yield of the Bourbon and related varieties; but too much importance should not be attached to these figures, as they only represent results from one plot of each variety each season.

TABLE VII.

YIELDS OF SUCROSE, 1893-7.

POUNDS PER ACRE.

Name of Cane.	1893.	1894.	1895.	1896.	1897.	Total.
White Transparent ..	3,547	2,667	1,737	7,902	6,621	22,474
Naga B.	1,836	1,927	1,848	8,271	5,047	18,529
Red Ribbon ...	3,926	1,708	?	6,061	4,324	16,119
Caledonian Queen ..	2,724	1,756	1,449	6,794	8,997	21,721
Bourbon	3,230	1,816	1,000	4,764	3,108	13,918
Queensland Creole ...	4,036	1,295	1,534	7,092	5,407	19,364
Trinidad No. 1 ..	2,262	997	1,088	4,520	4,720	13,587
Chigaca	2,796	1,763	1,373	5,286	2,964	14,182
Keni Keni . ..	4,593	2,378	999	3,675	1,079	12,724
Rappoe	2,003	1,699	985	5,245	6,095	16,017
Norman	3,022	1,004	1,398	5,107	5,404	15,935
Purple Mauritius ...	417	1,176	1,058	3,490	4,273	10,414
Lahaina	3,803	1,284	1,137	3,166	922	10,312
Seedling No. 1 ...	1,973	1,274	...	3,612	3,245	10,106
Seedling No. 2 ...	2,053	1,246	...	4,274	2,927	10,503
Seedling No. 3 ...	1,976	707	...	...	...	2,683

MILLING QUALITIES OF THE BOURBON CANE.

The superiority claimed for the Bourbon cane lay to a great degree in its excellent milling qualities. The fibre content of sugar-cane is known to vary largely in different varieties. The simplest indication of the fibre content is given by the percentage of juice expressed when the cane is crushed in the mill. It is obvious that canes with a high fibre content will yield less juice than those with a low one. It will be seen, therefore, that the percentage of juice yielded by the Bourbon cane should serve as an index to its fibre content.

Table VIII gives average percentages of juice yielded by crops of Bourbon cane on three estates from 1893-8. For the purpose of comparison, a statement is appended showing the percentage of juice obtained from a crop of White Transparent on two of these three estates during the years 1901-4. These results are probably a closer index of the true condition of affairs than could be obtained by crushing small lots of cane from experiment plots.

A comparison of these results shows that the Bourbon cane yielded a considerably higher percentage of juice than is obtained from the canes which have been substituted for it.

These results practically represent continuous work over a number of years, and they all show a tendency in the same direction. The drop in the percentage of juice extracted cannot be attributed to deterioration in the power of the mills, but rather to an increase in the fibre content of the canes, as a result of the substitution of the White Transparent for the Bourbon. When the White Transparent was substituted for the Bourbon in Antigua, it was found to be much more difficult to mill, and during the early years of its cultivation, frequent breakages in the mills are recorded.

TABLE VIII.

PERCENTAGE OF JUICE EXTRACTED BY MILL.

YEAR.	Estate A. Percentage of juice extracted by mill, average for crop.	Estate B. Percentage of juice extracted by mill, average for crop.	Estate C. Percentage of juice extracted by mill, average for crop.
1893	55·69	54·15	56·63
1894	56·93	52·81	52·64
1895	52·28	...	49·77
1896	56·88	...	51·08
1897	55·66	...	...
1898	52·00	52·85	...
1901	52·40	47·78	...
1902	55·06	51·46	...
1903	19·00	47·76	...
1904	...	18·53	...

MANURES AND RESISTANCE TO DISEASE.

The results obtained from the experiment plots at Skerrett's show that no relationship can be traced between the amount of rotten cane on each plot and the kind of manure applied. Reference to the planting of these fields would show that badly diseased areas occurred in patches and without respect to the manurial treatment of the plots. Messrs. Watts and Shepherd in considering the results obtained in the year 1896-7, dealt with this question fully, and plans of the fields were included in the reports on the experiments, indicating the position of the various plots and the yield of sound and rotten cane from each.* The series consisted of some twenty-nine experiments and included trials with all the more important manures, and with such substances as sulphate of iron, magnesia, and lime.

GENERAL CONCLUSIONS.

The preceding pages give a brief survey of the characters of the Bourbon cane under healthy conditions, and the circumstances which led to its abandonment as the principal cane in the Antigua sugar industry. It is proposed now to give a brief summary of the facts already presented, and to indicate the exact reason for the abandonment of the cultivation of the Bourbon.

It has been shown that the Bourbon cane was not generally superior to the varieties grown at the present time in the matter of yield per acre, and that it was extremely likely to suffer from unfavourable weather conditions. The saccharine content of its juice presented no mark of superiority. As a matter of fact, the amount of sugar contained in a gallon of Bourbon juice is at the present time considerably less than the sugar per gallon of juice from many of the varieties now cultivated. The planters considered that the Bourbon cane always gave good sugar-making juice; this may be interpreted to mean, that it contained relatively little gum. No records exist of the properties of the juice in this respect in the early days of the Bourbon sugar-cane cultivation. At the same time it is worthy of note, that during the earlier period of growth of this cane, the standard of quality of muscovado sugar was not as high as the present-day standard. Sale by polariscope test is a comparatively recent method, and even up to the last days of the Bourbon cultivation, sugar testing 87° was largely manufactured in Antigua, while the standard at the present time is 89°. The figures already given, relating to the milling qualities of the Bourbon cane, indicate clearly the soft and juicy character of this cane, and this is perhaps one of the most significant facts, and one which probably best accounts for the favour in which it was held by the planters. The difficulties of milling the Bourbon cane were far less than those experienced in milling the hardy varieties now grown.

Concisely stated, this means that the Bourbon cane contained relatively more juice and less fibre than most of the

* Report on the Results obtained at the Experimental field at Skerrett's, Manurial Experiments, 1896.

Report on the Results obtained at the Experimental field at Skerrett's, 1897.

new varieties. The term 'fibre' as applied in this connexion refers to the total content of insoluble matter, as contrasted with the liquid matter which includes the juice and the cell sap, and it appears likely that the cells in which the juice is contained, may be softer and contain less solid matter in the case of a juicy cane than in the case of a fibrous variety.

As to the effects of the attacks of rind fungus on the Bourbon cane, the fact which stands out most prominently is the rapidity with which this cane succumbed to the ravages of disease. The effect of the disease had been felt in some degree throughout the island, and in some instances had been severely felt; but sudden and marked deterioration set in in 1894, and it was clearly seen how great was the destructive force of the attack. Reference to Table IV will make clear the fact, that among the varieties introduced for trial in the island, only one or two, especially the Keni Keni and the Lahaina, show a liability to rind fungus attack as great as, or even greater than, that shown by the Bourbon, these two varieties being practically synonymous with the Bourbon.

Bourbon stock from other West Indian islands where the disease had not become so prevalent as in Antigua showed a susceptibility to disease when introduced into Antigua, equal to or greater than the native Bourbon stock.

It is important to note also, that no manurial treatment had any effect in lessening the attack on the Bourbon cane in Antigua. The rind fungus spreads itself throughout the body of the cane by means of its hyphae, which extend from one cell to another, living on the cell contents, eventually ramifying throughout the entire length and thickness of the cane. The fungus is probably enabled to penetrate cell walls and thus passes from one cell to another by means of a ferment which it secretes, and which possesses the power of dissolving the cell walls sufficiently to allow the hyphae to penetrate. It seems probable also, that the fungus existed in the West Indies for many years previous to the outbreak which led up to the abandonment of the cultivation of the Bourbon.

It has already been stated that, according to Massee, the rind fungus has probably developed from saprophytic ancestry. The following theory is put forward tentatively, as possibly explaining in some degree the manner in which the Bourbon cane succumbed to the attacks of the fungus.

Originally a saprophytic inhabitant, the rind fungus gradually became more and more strongly parasitic, and the power of the hyphae to penetrate cell walls became stronger and stronger, until the fungus became to all intents and purposes a purely parasitic disease well adapted to living and developing under the peculiar conditions afforded by the Bourbon cane. In this way, the time came when a strain of this fungus had been developed capable of penetrating the cell wall of the Bourbon with relative ease. It was not that the cane had become less resistant, but that the fungus had developed stronger powers of attack. It seems probable that the other canes which were substituted for the Bourbon enjoyed their immunity to attacks of this disease on account of their very high

fibre content, which offered sufficient resistance to the development of the disease to enable them to resist attack.

It is suggested that the sudden surrender of the Bourbon cane to the rind fungus confirms this theory. If the view of a gradually increased virulence on the part of the disease is correct, a point would be reached when the disease would have acquired sufficient strength to be able to overcome the resistance offered by the structure of the cane, more especially under conditions unfavourable to the cane, and possibly favourable to the development of the disease. This theory is put forward as affording a reasonable explanation of the facts as they are known to have occurred. So far as the writer is aware, this view of the situation has not previously been advanced.

Rind fungus is known in practically every cane-producing country, but it has only been in a few instances that attacks have proved so virulent as to render the growth of the Bourbon an impossibility, and as the cane can lay claim to have been cultivated for equally long periods of time elsewhere, it is difficult to see why the Antigua strain of Bourbon should be weaker than those of other parts of the world. To this view confirmation is added by the fact that imported strains of the variety showed themselves equally incapable of resisting the disease with the native stock.

The theory usually accepted with regard to the method by means of which the disease gains entrance to the soft tissues of the cane is that the spores of the fungus carried by the wind, penetrate by means of the tunnels made by the moth borer and weevil borer, or by accidental injury.

The view that the disease is spread by planting infected tops has not been generally accepted. Questions with regard to the spread of rind fungus, however, have become relegated to the background as a result of the comparative immunity from the disease which the canes now cultivated in Antigua enjoy, and with the need for the consideration of other and more pressing problems. Nevertheless the rind fungus is always with us. This is shown by the fact that almost any cane grown in Antigua will develop the typical hair-like spores of *Trichosphaeria sacchari*, if cut and kept under proper conditions. This would make it appear that the disease is still being propagated with the cane, and would lend a certain amount of support to the theory that the disease is spread by means of infected tops. It would seem also that this propagation of the disease had been going on for a considerable time previous to the period covered by this paper; and if this was so, it would have served to strengthen the parasitic habit of the fungus.

The logical conclusions of the theory outlined above would result in the belief that the rind fungus might go on increasing in the strength of its parasitic habit until able to overcome the resistance of varieties more fibrous than the Bourbon. At the same time, it is possible that the resistance of a cane to disease may be a somewhat complex function. It may be that the resistant powers of any one variety may depend on the strain of the fungus by which it is attacked; that each variety may

be liable to severe attack by one particular strain of fungus: that, in short, a kind of lock and relationship may exist between the strain of fungus and the variety of cane. Hence it is possible that, at the present time, the observed immunity from rind fungus may be attributed to the increased number of varieties grown. It is significant, in this connexion, that, as far as the writer is aware, the small areas of Bourbon cane now grown in Antigua have not for several years suffered to such a marked degree from rind fungus as was shown in former times.

The series of sugar-cane experiments conducted in Antigua and St. Kitt's since 1899 furnishes a very significant point. Formerly a considerable amount of rotten cane was recorded from the plots of varieties, especially in the case of the White Transparent; but since 1902 no appreciable amount of rotten cane has been recorded from any of the experiment plots from varieties. This would appear to show that the disease has decreased in virulence towards the White Transparent varieties.

GENERAL SUMMARY.

1. In the yield of cane per acre the Bourbon did not differ greatly from the varieties grown at the present time.

2. The effect of the rind fungus is shown by the amount of rotten cane found in the field.

3. The juice of the Bourbon gave about 1·9 lb of sugar to the gallon, and was somewhat less rich than the juice commonly met with at present.

4. The effect of the disease on the juice was seen in the diminution of sucrose content and rise in the glucose ratio. This was severely felt in the process of manufacture.

5. The Bourbon was a very juicy cane, containing less fibre and giving better milling results than the varieties grown at the present time.

6. No form of manurial treatment appeared to make the cane more resistant.

7. The breakdown of the Bourbon was, in the end, relatively very sudden. It was not only the native Bourbon cane that showed liability to rind fungus: other related varieties and imported uninfected Bourbon stock showed equal liability to it when grown in Antigua.

8. It is probable that *Trichosphaeria sacchari* was originally saprophytic and has subsequently developed parasitic tendencies: it has probably existed in the West Indies for many years.

9. The manner in which the fungus passes through the cane is probably, that the fungus threads secrete a ferment capable of dissolving a passage through the cell walls.

10. The Bourbon cane being less fibrous than the White Transparent probably possessed cell walls more easily penetrable. Consequently it is suggested that the sudden breakdown of the Bourbon was due to an increase in virulence of the

fungus which enabled it to pass from cell to cell with relative ease in the case of that cane, while the White Transparent, being more fibrous, offered more resistance.

11. Most canes grown at the present time in Antigua will, on keeping, develop the typical spores of *Trichosphaeria.*

12. The most generally accepted theory regarding the spread of the disease, is that of wound infection by means of wind-blown spores. The theory that the disease is spread by the planting of infected material has much in its favour, however, for this practice would serve admirably for the intensification of the parasitic habit of the fungus.

ADDENDUM.

The interesting suggestion has been advanced by Mr. A. Spooner of Bendal's, Antigua, that a contributing cause of the abandonment of the Bourbon cane was root disease (*Marasmius sacchari*), in addition to rind fungus (*Trichosphaeria sacchari*).

According to this idea, the plant canes having fallen victims to rind fungus, the ratoon stools, depleted of their vigour, readily succumbed to root disease.

While at this distant date it is impossible to say definitely whether this was the case or not, at the time of the abandonment of the Bourbon, *Marasmius sacchari*, as a distinct and specific disease of the sugar-cane, was not recognized. The suggestion, however, is of interest, and is likely to be near the truth.

In this connexion, the following passage taken from the Report on the Experiments at Skerrett's, for 1896-7, is of interest:-

'The chief disease from which the canes of the island is suffering is rind fungus (*Trichosphaeria*). Although many other pests are present, the amount of damage wrought by these is small compared with the loss attributable to rind fungus. A disease known locally as "root disease," which causes young ratoon canes to die out in patches, has created anxiety in some districts; the cause does not appear to be clear. By some it is regarded as a phase of rind fungus, by others as a specific disease. We incline to the latter opinion in connexion with some of the outbreaks on calcareous soils. This disease often occurs in places where the soil is highly calcareous; for instance, in places where the soil contains carbonates of alkaline earths equal to 40 to 50 per cent. of carbonate of lime. It cannot therefore be attributed to a deficiency of lime in the soil, as some writers have suggested.'

COMPARISON OF THE BOURBON SUGAR-CANE WITH THE WHITE TRANSPARENT AND OTHER VARIETIES AT BARBADOS.

BY J. R. BOVELL, I.S.O., F.L.S., F.C.S.,

Superintendent of Agriculture, Barbados.

From time to time various writers in the press, and several sugar planters in the course of conversation have expressed the opinion that an effort should be made to resuscitate the Bourbon sugar-cane, which they refer to in eulogistic terms as the 'good old Bourbon cane.' and the 'good old days when only the Bourbon cane was cultivated.' It may not be without interest if a brief history is given of the results obtained with this cane prior to the time when it succumbed to the joint attacks of the various fungi prevalent in 1894-6, and for the twelve years 1897 to 1908 when other canes have been grown.

In 1899, in view of the uncertainty that had always existed in Barbados as to the area under the various crops, an effort was made to obtain accurate information, by means of a circular letter to the proprietor, attorney, or manager of each estate, asking that a form, which was enclosed, should be filled up and returned, showing the acreage under each crop. Unfortunately, the returns were received from only about half of the estates, and so absolutely accurate data were not obtainable. However, as the returns were received from all of the districts of the island, it was possible to calculate approximately the areas under the various crops, on the assumption that they were grown on the remaining estates in the same proportion as they were on those estates from which returns were received. On this basis, it was found that the approximate area under canes was, in round numbers, 35,000 acres. Judging from my knowledge of the island, this was about the average acreage from which sugar-canes were reaped annually. Some time ago, I tabulated the average rainfall and the sugar crops of the island for the thirty-five years prior to the time the Bourbon cane succumbed to the attacks of the fungoid diseases that were so prevalent in 1895 and 1896. It will be seen by referring to Table I, that the average annual sugar crop of the island was 46,515 tons of sugar, with an average rainfall of 61·94 inches. As during the years 1895 and 1896, the White Transparent, together with certain of the seedling canes, was being substituted for the Bourbon, these two years have been omitted. For the twelve years since then, i.e., from 1897-1908 inclusive, during which the average rainfall was 62·31 inches, the average sugar crop of the island has been 46,961 tons (see Table II), obtained from sugar-canes other than Bourbon; that is to say, has averaged 446 tons more than the average for the thirty-five years during which the Bourbon cane alone was planted. I may mention that in calculating the sugar produced during the years in which syrup was shipped, i.e., from 1904-8, I have deducted the puncheons of syrup which are included in the Customs return with the molasses crop, and equated them into tons of sugar.

TABLE I.

AVERAGE RAINFALL AND SUGAR CROPS OF THE ISLAND OF BARBADOS, FOR THIRTY-FIVE YEARS 1860-94, INCLUSIVE.

YEAR.	Rainfall in inches.	Sugar Crop in hogsheads.	YEAR.	Rainfall in inches.	Sugar Crop in hogsheads.
1860	57·96	42,684	1878	73·02	43,511
1861	73·79	49,845	1879	74·47	57,146
1862	59·16	46,120	1880	69·10	54,217
1863	42·46	42,281	1881	70·67	51,433
1864	59·14	36,199	1882	50·06	54,937
1865	68·59	47,209	1883	62·30	52,851
1866	59·68	57,241	1884	59·75	62,085
1867	69·88	53,398	1885	45·17	67,764
1868	44·59	58,242	1886	85·87	45,769
1869	48·43	32,835	1887	69·01	68,872
1870	59·34	39,270	1888	69·09	73,009
1871	41·90	53,907	1889	76·92	65,268
1872	48·70	39,167	1890	52·53	85,261
1873	51·26	37,337	1891	66·30	50,547
1874	59·22	47,293	1892	86·46	59,254
1875	61·61	65,000	1893	76·18	67,157
1876	52·75	37,347	1894	46·71	66,262
1877	75·97	49,879	Total	2,168·04	1,860,597

Average rainfall for 35 years, 61·94.

Average crop „ „ „ 53,160 hogsheads, which is equal to 46,515 tons.

A hogshead of sugar is equal to $\frac{7}{8}$ ton. The average annual sugar crop of the island for the thirty-five years was therefore 46,515 tons.

TABLE II.

AVERAGE RAINFALL AND SUGAR CROPS OF THE ISLAND OF BARBADOS, FOR THE TWELVE YEARS 1897-1908, INCLUSIVE.

YEAR.	Rainfall in inches.	Sugar Crop in tons.	Syrup, equal to sugar, in tons.	Sugar Crop in tons.
1897	73·05	51,275	...	51,275
1898	69·41	46,878	...	46,878
1899	50·80	40,442	...	40,442
1900	61·97	44,250	...	44,250
1901	91·89	56,912	...	56,912
1902	56·05	45,576	...	45,576
1903	67·42	33,795	...	33,795
1904	59·38	55,785	151	55,936
1905	54·59	41,210	2,239	43,449
1906	70·70	50,630	7,296	57,926
1907	47·68	33,033	12,462	45,495
1908	44·78	31,353	10,248	41,601
Total	747·72	531,139	32,396	563,535
Average	62·31			46,961

From 1897 to 1903 inclusive, prior to the first year syrup was shipped, the average quantity of molasses exported per ton of sugar was 88 wine gallons, and as the average quantity per puncheon shipped is 110 wine gallons, the quantity of sugar equal to the syrup shipped, on the basis of 315 gallons of syrup of 41 Beaumé being equal to 1 hhd. of sugar and 80 gallons of molasses, has been added to the crop from 1904 to 1908.

It might be argued by those not conversant with the agriculture of the island, that during these twelve years a larger acreage has been reaped owing to the fact that ratoons have been kept to a greater extent than when only the Bourbon was grown. It may be mentioned, in this connexion, that during these twelve years a greater quantity of sweet potatos has been grown for sale, on lands which had previously been

planted in sugar-cane, and in addition, that during the last seven years, i.e., from 1902-3 to 1907-8 inclusive, 16,657 acres of cotton have been cultivated, or an average of about 2,400 acres each year. Furthermore, a number of estates have been sold in small lots to peasants who, to a great extent, have grown provision crops on their lands instead of canes. I am therefore of opinion, that the area under sugar-canes during the past twelve years has been less, on the average, than during the thirty-five years mentioned above when the Bourbon was practically the only cane grown in the colony.

With the view of ascertaining whether it was possible to increase the healthiness and vigour of the Bourbon cane, by planting only the best plants, and by carefully manuring, this cane has been grown under these conditions at Dodd's in the same field and under the same conditions as the White Transparent and the seedling canes B. 147, B. 208, and others, for the ten years 1898-1907. The full results are given in Table III, but the average yield of saccharose per acre, and the increase on the Bourbon are shown in Table IV.

TABLE III.

AVERAGE RESULTS OBTAINED FROM THE BOURBON, WHITE TRANSPARENT, B. 147, AND B. 208, CULTIVATED IN THE SAME FIELD AT DODDS, FOR THE TEN YEARS 1898-1907, INCLUSIVE.

	Bourbon.	White Transparent.	B. 147.	B. 208.
Tons of cane per acre	21·89	26·55	33·84	25·49
Per cent. by number of rotten cane	18·28	0·19	3·42	5·79
Saccharose, lb. per gallon of juice	1·794	1·994	1·873	2·215
Glucose, „ „ „ „ „	0·110	0·072	0·101	0·053
Quotient of purity	85·86	89·57	87·36	90·42
Glucose ratio	6·30	3·66	5·44	2·43
Gallons of juice per acre	2,762	3,324	4,396	3,117
Saccharose in juice, lb. per acre	4,952	6,615	8,157	6,834

It will also be noted that the percentage of rotten canes amounted in the case of the Bourbon to 18·28 per cent. while the White Transparent had 9·19 per cent.; B. 208, 5·79 per cent.; and B. 147, 3·42 per cent. It will also be observed that the 'glucose ratio' on the average for the Bourbon during that period was such as to make it doubtful whether muscovado sugar testing 89° could have been made from it.

TABLE IV.

Name of cane.	Saccharose, lb. per acre.	Increase on the Bourbon, lb. per acre.
Bourbon	4,952	...
White Transparent	6,615	1,663
B. 208.	6,831	1,869
B. 147.	8,157	3,205

During the whole of the ten years, with one exception, the Bourbon cane has been attacked by fungoid diseases, some years more than others. This year I have detected in the plot at Dodd's, *Marasmius sacchari*, Wakker; *Colletotrichum falcatum*, Went; *Trichosphaeria sacchari*, Mass.; and *Diplodia* sp. During the past ten years, here and there about the island certain of the planters have, from time to time, grown a few Bourbon canes, with the object of ascertaining whether they had become sufficiently immune to the attacks of fungi to produce normal crops. In some years they have been better than others, but owing to the drought that existed during the past year, there is no estate, so far as I know, that has grown Bourbon canes which have not been badly attacked by fungoid diseases, and have not given considerably less sugar than other canes grown on the same estates.

From the foregoing it will be seen that the statments which have been made from time to time, but which are unsupported by any data, with regard to the Bourbon sugar-cane giving considerably better yields in Barbados than the canes that have been planted in recent years, are not borne out by the statistics of the colony.

THE SOILS OF NEVIS.

BY FRANCIS WATTS, C.M.G., D.Sc., F.I.C., F.C.S.,

AND

H. A. TEMPANY, B.Sc., F.I.C., F.C.S.

The following paper is a further contribution toward the knowledge of the soils of the Leeward Islands group. The study of these soils has been carried on as time and opportunity have permitted during the past nine years. The results of the study of the soils of Dominica and Montserrat have already been published.*

Nevis is a volcanic island of about the same geological age as St. Kitt's and Montserrat, though possibly somewhat more recent. Its physical form is the simplest of all the Leeward Islands group, consisting of a main central peak with the land sloping down to the sea, approximately evenly on all sides.

The results of the analyses show that the soils of the various cultivated lands, which form a fairly even belt along the coast around the central peak, would, in the physical characters at any rate, present closer resemblances than other islands of the group whose physical configurations exhibit more varied features.

The samples examined were collected during 1906-7 by the Agricultural Instructors acting under direction from the Government Laboratory for the Leeward Islands. In each case, soil to the depth of 1 foot was taken from various parts of the field and the whole mixed together so as to form a representative sample.

Fourteen samples were collected and have been examined. Although this is not a large number, it gives a fair idea of the soil characters of the island.

The various factors and constituents determined, and the methods of analysis employed, which are similar to those used in the examination of the soils of Montserrat (*loc. cit.*), are again detailed below.

In each sample of soil there have been determined:—

The phosphoric acid soluble in 1 per cent. citric acid solution;

The potash soluble in 1 per cent. citric acid solution;

The carbon dioxide evolved on treatment with hydrochloric acid;

The total nitrogen;

The carbon existing in the form of organic matter.

These being the components upon which, from a chemical point of view, the fertility of soils chiefly depends, it would appear that the determination of these is sufficient to enable one to judge of their capabilities and requirements.

In order that the chemical results may be readily interpreted, the following arbitrary standards in connexion with

* See Soils of Montserrat, *West Indian Bulletin*, Vol. VI, p. 263, and *Report on Soils of Dominica*, Imperial Department of Agriculture, 1902.

each constituent may be employed to determine whether a constituent may be regarded as present in large, small, or medium quantities :—

Assimilable potash	above	0·01 per cent.	high
„ „	·005 to	0·01 „ „	medium
„ „	less than	0·005 „ „	low
Assimilable phosphate	above	0·02 „ „	high
„ „	·01 to	0·02 „ „	medium
„ „	less than	0·01 „ „	low
Carbonates, in terms of carbonate of lime	above	0·5 „ „	high
„ „	0·1 to	0·5 „ „	medium
„ „	less than	0·1 „ „	low
Nitrogen	above	0·15 „ „	high
„	0·1 to	0·15 „ „	medium
„	less than	0·1 „ „	low
Organic matter	above	0·2 „ „	high
„ „	0·1 to	0·2 „ „	medium

In addition to the chemical analysis each sample has been submitted to mechanical analysis by Osborne's beaker method. The results of this are given in figures and also diagramatically for more easy comparison.

The separated constituents are classed as follows according to size of particles :—

	Millimetres.			*Inches.*		
Stones ...	...above 5			above 0·2		
Coarse gravel ...	5	to	2	0·2	to	0·08
Gravel	2	„	1	0·08	„	0·04
Coarse sand ...	1	„	0·5	0·04	„	0·02
Medium sand ...	0·5	„	0·25	0·02	„	0·01
Fine sand	0·25	„	0·1	0·01	„	0·004
Very fine sand ...	0·1	„	0·05	0·004	„	0·002
Silt	0·05	„	0·01	0·002	„	0·0004
Fine silt	0·01	„	0·005	0·0004	„	0·0002
Clay ... less than	0·005		less than	0·0002		

The following is a list of the localities from which samples have been collected and analysed :—

Botanic Station, plot F, Botanic Station, plot G, Farm, Hamilton's, Morning Star, Cock's Heath, Indian Castle, New River, Madden's, Potwork, Round Hill, Spring Hill, Clifton's, and Pinney's.

BOTANIC STATION.

The Botanic Station is situated on the western side of the island about 1 mile to the south-east of Charlestown and occupies about an acre of ground. It is divided into $\frac{1}{10}$-acre plots. The sample of soil from plot F was taken on the left of the central path approaching the office, and the one from plot G on the right-hand side.

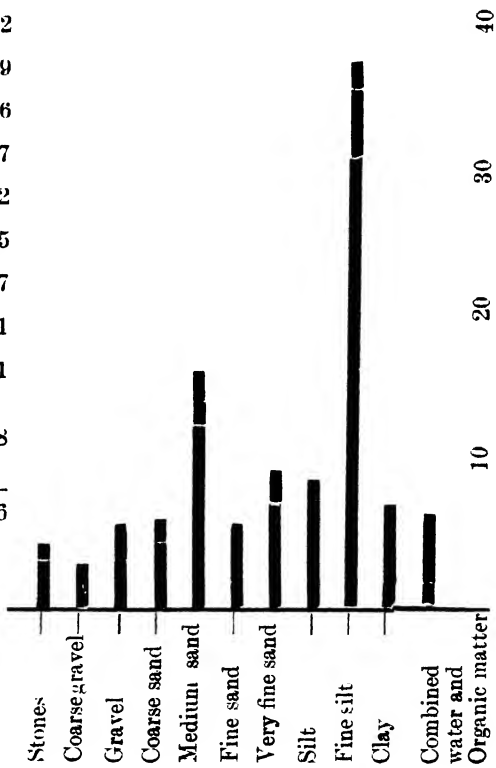
PLOT F.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0134	per cent.
Potash „ „ „ „ „	0·0298	„ „
Carbon dioxide	0·108	„ „
Equal to carbonate of lime	0·245	„ „
Nitrogen	0·210	„ „
Organic carbon	1·549	„ „
Equal to humus	2·672	„ „

PHYSICAL COMPOSITION (per cent.).

Stones	3·8
Coarse gravel ...	2·2
Gravel	4·9
Coarse sand ...	5·6
Medium sand ...	15·7
Fine sand ...	5·2
Very fine sand ...	8·5
Silt	7·7
Fine silt	35·1
Clay	6·1
Organic matter and combined water	5·8
	100·6



Agricultural clay	41·2
Water retained by water-free soil	55·9

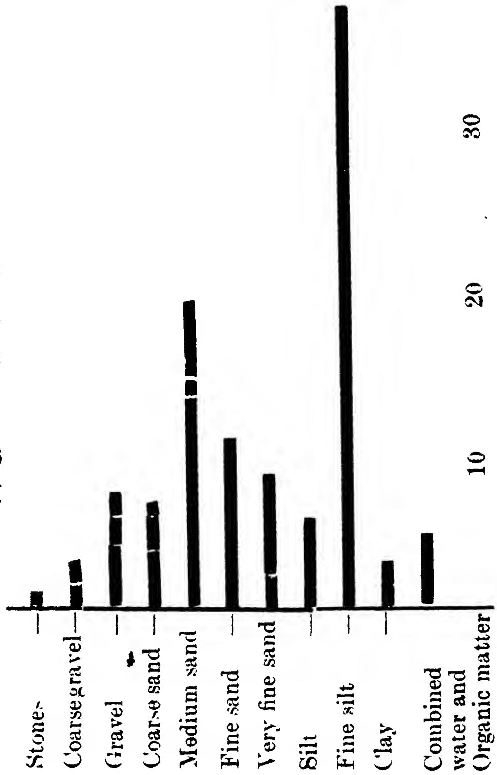
PLOT G.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·048	per cent
Potash „ „ „ „ „	0·0329	„ „
Carbon dioxide	0·023	„ „
Equal to carbonate of lime	0·052	„ „
Nitrogen	0·148	„ „
Organic carbon	1·207	„ „
Equal to humus	2·130	„ „

PHYSICAL COMPOSITION (per cent.).

Stones	0·4
Coarse gravel ...	2·4
Gravel	7·0
Coarse sand ...	6·7
Medium sand ...	18·9
Fine sand ..	10·4
Very fine sand ...	8·1
Silt	5·2
Fine silt	37·2
Clay	2·8
Organic matter and combined water	4·6
	103·7



Agricultural clay	40·0
Water retained by water-free soil	51·9

In physical character these soils, as might be expected, closely resemble one another, being moderately light sandy loams; there are 41·2 and 40·0 per cent. of agricultural clay respectively, in F and G. The sand and clay constituents are well blended, producing a soil easily worked, and easily maintained in good tilth.

The chemical analysis shows that both plots are well supplied with assimilable potash and phosphate, which are present in large amounts, plot G being especially marked in this respect.

They are also well supplied with nitrogen, and organic matter and humus are present in moderate quantities.

Plot G, like the majority of Nevis soils, is sparsely supplied with carbonate of lime. Plot F, on the other hand, possesses

a moderate amount, the quantity found being far in excess of any other Nevis soil. It would seem probable that this plot had received a dressing of lime at some recent date.

FARM.

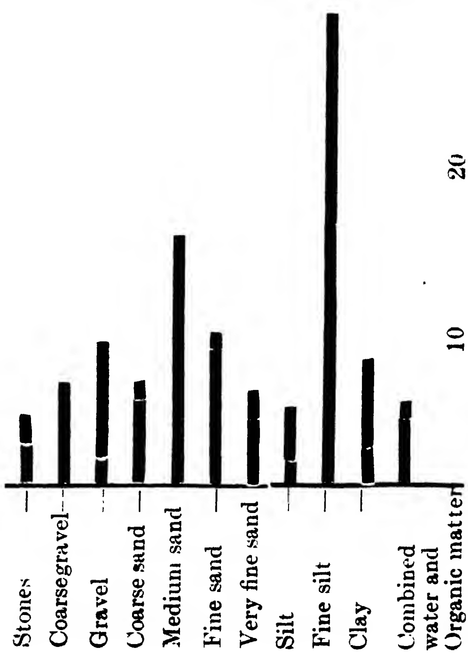
This estate is situated about 1 mile south-east of Charlestown and adjoins the Botanic Station. The field from which the sample was taken was near the sea, at an elevation of 60 feet.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0035	per cent.
Potash " " " " "	0·0428	" "
Carbon dioxide	0·030	" "
Equal to carbonate of lime	0·068	" "
Nitrogen	0·104	" "
Organic carbon	0·800	" "
Equal to humus	1·879	" "

PHYSICAL COMPOSITION (per cent.).

Stones	3·8
Coarse gravel ...	6·6
Gravel	9·1
Coarse sand ...	6·3
Medium sand ...	15·5
Fine sand ..	9·5
Very fine sand ...	4·4
Silt	4·7
Fine silt	28·7
Clay	7·9
Organic matter and combined water	4·7
	101·2



Agricultural clay	36·6
Water retained by water-free soil	60·4

With regard to plant food constituents, the soil is supplied with organic matter in moderate amount while, in common with other West Indian volcanic soils, it is deficient in available phosphate, but is supplied with a very large amount of available potash.

The physical character of this soil is good. It is a sandy loam, fairly retentive of water, readily worked and maintained in good tilth. Green dressings and pen manure should prove of value in maintaining it in good condition.

HAMILTON'S.

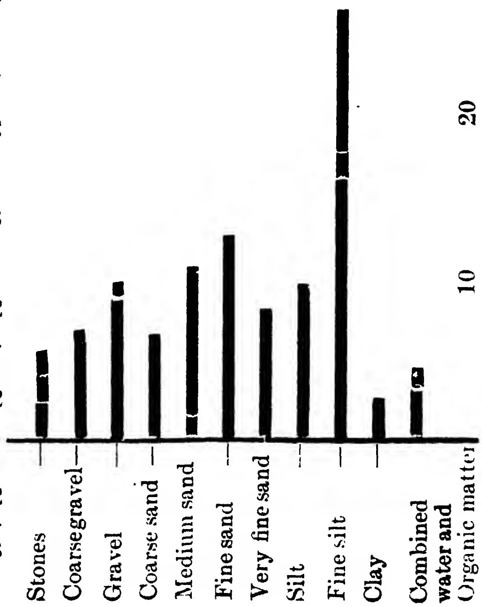
This estate is situated about 1 mile due east of Charlestown, at an elevation of 450 feet. The sample for analysis was taken from a field situated on the east of the estate about 500 yards from the boiling house.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0027	per cent.
Potash „ „ „ „ „	0·0138	„ „
Carbon dioxide	0·044	„ „
Equal to carbonate of lime	0·100	„ „
Nitrogen	0·137	„ „
Organic carbon	1·579	„ „
Equal to humus	2·727	„ „

PHYSICAL COMPOSITION.

Stones	5·4
Coarse gravel ..	7·1
Gravel ...	9·7
Coarse sand ...	6·2
Medium sand ...	10·7
Fine sand ...	12·8
Very fine sand ...	8·1
Silt	9·2
Fine silt	26·7
Clay	3·2
Organic matter and combined water	4·2
	103·3



Agricultural clay	29·9
Water retained by water-free soil	48·5

The soil is amply supplied with humus, and is, presumably, in excellent tilth. Nitrogen is present in moderate amount. The amount of carbonate of lime present is small, though somewhat in excess of the average amount found in these soils.

The sample is markedly deficient in assimilable phosphates, but is remarkable for the very large amount of assimilable potash present.

Physically, the soil is a light sandy loam moderately retentive of water, easily worked and maintained in tilth.

MORNING STAR.

This estate is situated about 2 miles to the east-south-east of Charlestown, at an elevation of 500 feet.

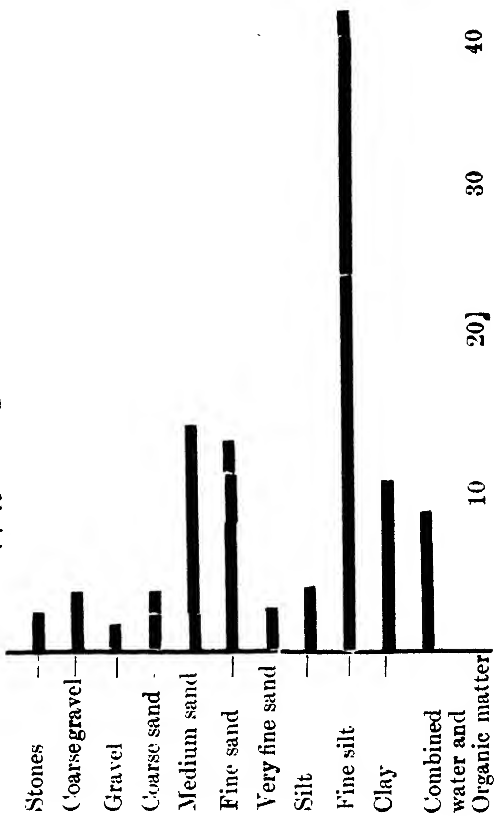
The field from which the sample was taken is situated on the western side of the estate adjoining Cane Garden lands.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0032	per cent.
Potash " " " " "	0·0081	" "
Carbon dioxide	0·035	" "
Equal to carbonate of lime	0·079	" "
Nitrogen	0·129	" "
Organic carbon	1·699	" "
Equal to humus	2·929	" "

PHYSICAL COMPOSITION.

Stones	2·4
Coarse gravel ...	3·4
Gravel	1·3
Coarse sand ...	3·2
Medium sand ...	13·8
Fine sand ...	13·0
Very fine sand ...	2·4
Silt	3·4
Fine silt	40·7
Clay	10·9
Organic matter and combined water	8·2
	102·7



Agricultural clay	51·6
Water retained by water-free soil	64·8

The soil is moderately well supplied with potash, but is deficient in phosphates, and in calcium carbonate. Nitrogen is present in moderate amount, while the supply of humus is ample.

Physically, the soil is a loam somewhat heavier in character than the average Nevis soil, the proportion of agricultural clay being higher than in other cases. It is fairly easily worked and kept in condition, but for the maintenance of tilth it is essential that the supply of humus should be maintained. Phosphatic manures, under certain conditions, would probably prove of value.

This and the four preceding samples represent fairly well the soils of the district to the south and east of Charlestown in the western district of the island.

COCK'S HEATH.

This estate is situated on the southern side of the island close to the coast, about 4 miles from Charlestown.

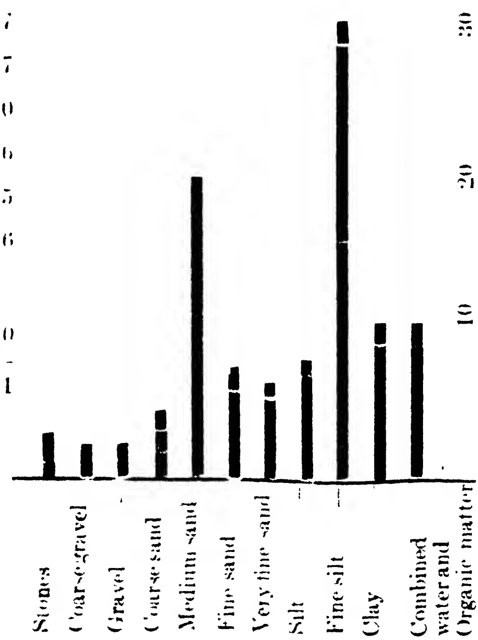
The sample was taken from newly cleared land situated about 56 feet above sea-level.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0146	per cent.
Potash	0·0107	„ „
Carbon dioxide	0·038	„ „
Equal to carbonate of lime .. .	0·086	„ „
Nitrogen	0·230	„ „
Organic carbon	2·962	„ „
Equal to humus	5·106	„ „

PHYSICAL COMPOSITION.

Stones	2·6
Coarse gravel ..	1·7
Gravel	1·8
Coarse sand ..	3·9
Medium sand	19·7
Fine sand .	7·7
Very fine sand .	6·0
Silt	7·6
Fine silt	29·5
Clay	10·6
Organic matter and combined water	10·0
	101·1



Agricultural clay	10·1
Water retained by water-free soil	57·1

As is to be expected, the soil is very rich in nitrogen and organic carbon. It is moderately well supplied with phosphates and well supplied with potash. There is the usual deficiency of calcium carbonate.

Physically, it is a moderately light, sandy loam, easy to work and maintain in tilth.

The large amount of organic matter at present contained in it will render it very fertile, but with the decay of the organic matter, it will become necessary to maintain its tilth by means of pen manure and green dressings.

INDIAN CASTLE.

This is situated on the southern coast about 3½ miles east of Cock's Heath.

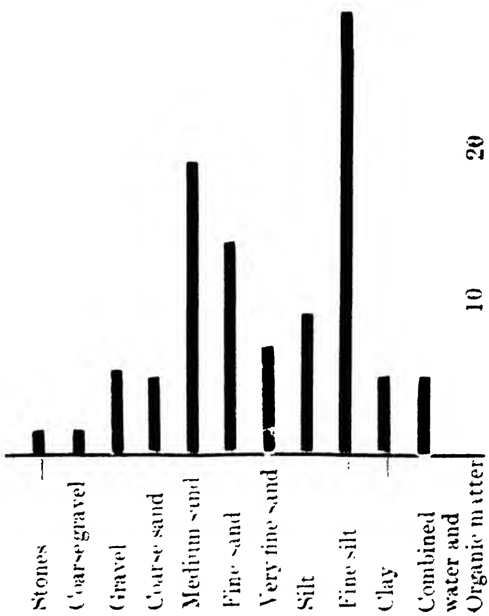
The field from which the sample was taken is situated at the south-east of the estate, at an elevation of 40 feet.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0019	per cent.
Potash ,, ,, ,, ,, ,,	0·0231	,, ,,
Carbon dioxide	0·035	,, ,,
Equal to carbonate of lime	0·079	,, ,,
Nitrogen	0·132	,, ,,
Organic carbon	1·804	,, ,,
Equal to humus	3·111	,,

PHYSICAL COMPOSITION.

Stones	1·2
Coarse gravel ...	1·6
Gravel	5·2
Coarse sand ...	5·0
Medium sand ..	18·3
Fine sand ..	13·2
Very fine sand ...	6·5
Silt ..	8·9
Fine Silt ...	27·8
Clay	4·9
Organic matter and combined water	5·0
	97·6
Agricultural clay	32·7
Water retained by water-free soil	50·5



This soil is well supplied with assimilable potash but is very deficient in phosphate. The amount of carbonate of lime is, as usual, small. The supply of nitrogen and organic matter is moderate, but sufficient.

The physical examination of the soil shows it to be a loam containing a rather large percentage of clay.

It should, however, be a fairly easy matter to maintain its tilth, in which process, the free use of green dressings and pen manure combined with moderate application of lime should prove of value.

POTWORK.

This estate is situated on the north-east coast about 1½ miles north of Madden's.

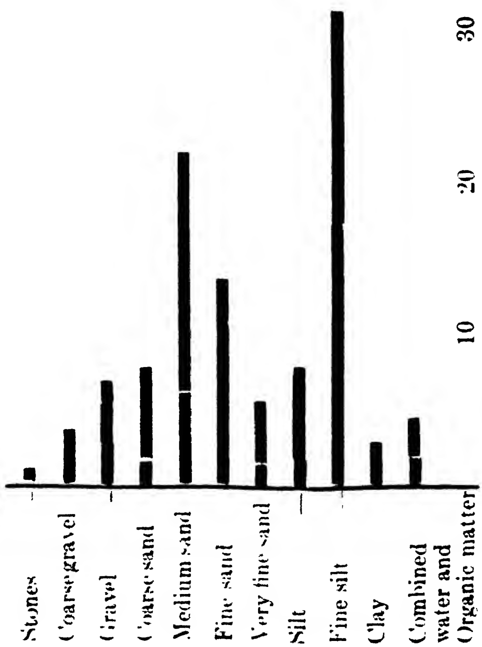
The field from which the sample was taken is situated on the eastern side of the estate, at an elevation of 70 feet.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0126	per cent.
Potash „ „ „ „	0·0151	„ „
Carbon dioxide	0·034	„ „
Equal to carbonate of lime	0·077	„ „
Nitrogen	0·109	„ „
Organic carbon	1·248	„ „
Equal to humus	2·152	„ „

PHYSICAL COMPOSITION.

Stones	0·8
Coarse gravel . .	3·1
Gravel	6·7
Coarse sand ..	7·7
Medium sand .	21·2
Fine sand	13·4
Very fine sand	5·1
Silt . ..	7·5
Fine silt	30·2
Clay ..	2·5
Organic matter and combined water	4·1
	102·6
Agricultural clay	32·7
Water retained by water-free soil	47·0



The supply of available potash is, as usual, good, while assimilable phosphate is present in sufficient amount, wherein the soil differs from most of the other members of the group.

The content of carbonate of lime is low as usual, whilst the supply of nitrogen and organic matter is moderate, but sufficient. In physical constitution, the soil closely resembles the majority of those examined, being moderately light, and draining freely.

ROUND HILL.

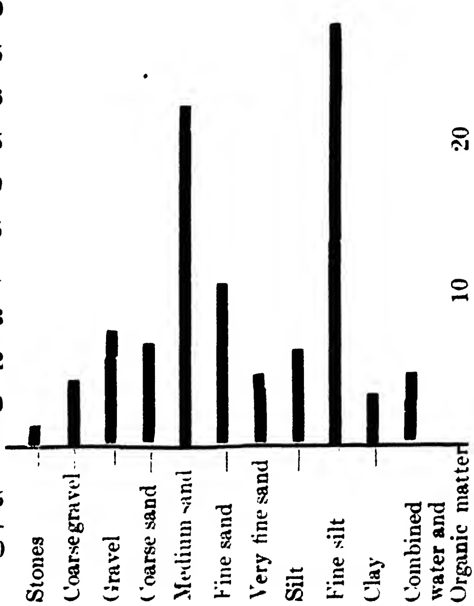
Round Hill estate is situated in the extreme north of Nevis, in a hollow near the coast, about 3 miles west of Potwork. The field from which the sample was taken is located about 300 yards east of the estate buildings, and 6 feet above sea-level.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0078	per cent.
Potash „ „ „ „ „	0·0136	„ „
Carbon dioxide	0·0136	„ „
Equal to carbonate of lime ...	0·042	„ „
Nitrogen	0·094	„ „
Organic carbon	1·083	„ „
Equal to humus	1·867	„ „

PHYSICAL COMPOSITION.

Stones	1·0
Coarse gravel ...	4·5
Gravel	7·6
Coarse sand ...	9·5
Medium sand ...	21·9
Fine sand ...	10·5
Very fine sand ...	4·1
Silt	6·3
Fine silt	27·2
Clay	2·9
Organic matter and combined water	4·5
	100·0
Agricultural clay	30·1
Water retained by water-free soil	55·4



The soil is, as usual, well supplied with available potash. Assimilable phosphate, though present in somewhat larger amount than met with in other members of the group, is nevertheless somewhat deficient. Carbonate of lime is again deficient. Nitrogen is present in moderate but sufficient amount, while the supply of organic matter is fair.

Physically, the soil is a light sandy loam capable of easy and economical working, and moderately retentive of moisture.

SPRING HILL.

This estate is situated in the north-western portion of the island about 1 mile from the coast, 4 miles north of Charlestown, and 2 miles south of Round Hill.

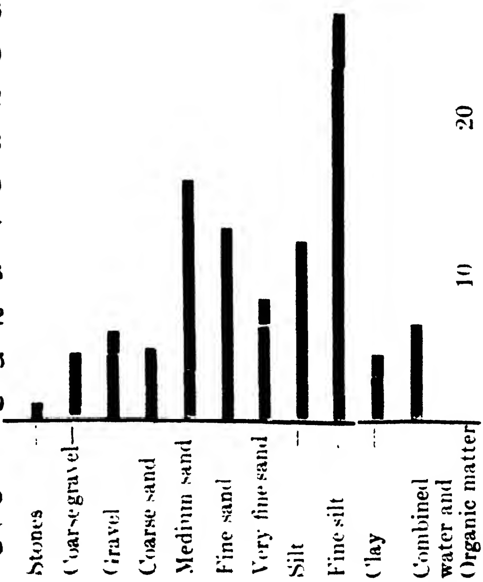
The sample was taken from a field on the western side of the estate yard, at an elevation of 280 feet.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0045	per cent.
Potash „ „ „ „ „	0·0176	„ „
Carbon dioxide	0·024	„ „
Equal to carbonate of lime ..	0·055	„ „
Nitrogen	0·126	„ „
Organic carbon	1·081	„ „
Equal to humus	1·864	„ „

PHYSICAL COMPOSITION.

Stones	0·6
Coarse gravel ...	4·0
Gravel	5·2
Coarse sand ...	4·3
Medium sand ...	14·9
Fine sand ...	12·7
Very fine sand ...	7·6
Silt	11·2
Fine silt	26·6
Clay	1·9
Organic matter and combined water	6·9
	98·9
Agricultural clay	31·5
Water retained by water-free soil	41·1



Available potash is well supplied, while available phosphates and carbonate of lime are deficient Nitrogen is present in medium amount, while organic matter has a tendency to be deficient.

Physically, the soil resembles others of the Nevis group, being light, readily worked, and moderately retentive of moisture. The growth of green dressings and the application of pen manure would probably prove beneficial in this soil.

CLIFTON'S.

This estate is situated on the western side of Nevis about 1 mile south of Spring Hill.

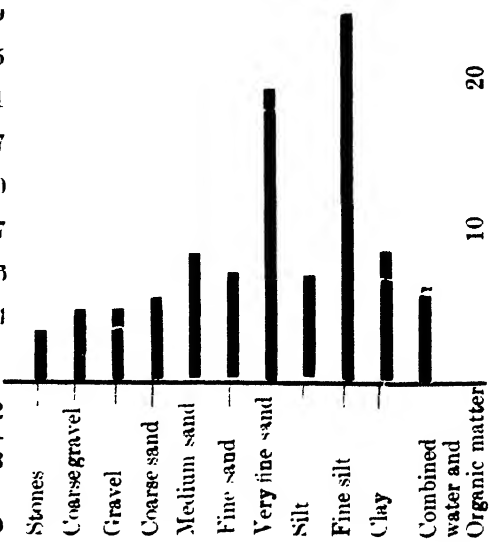
The field from which the samples were taken is situated about 200 yards west of the estate buildings, at an elevation of 80 feet.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0053	per cent.
Potash " " " " "	0·0178	" "
Carbon dioxide	0·022	" "
Equal to carbonate of lime	0·050	" "
Nitrogen	0·140	" "
Organic carbon	0·965	" "
Equal to humus	1·663	" "

PHYSICAL COMPOSITION.

Stones	3·8
Coarse gravel ...	4·9
Gravel	4·9
Coarse sand ...	5·5
Medium sand ...	8·1
Fine sand ...	18·7
Very fine sand ..	7·0
Silt	5·7
Fine silt	23·6
Clay	8·1
Organic matter and combined water	6·2
	96·8
Agricultural clay	32·0
Water retained by water-free soil	41·9



The chemical composition of the soil presents a close parallel to that of others already examined. Available potash is well supplied while phosphoric acid is deficient, and the usual deficiency of carbonate of lime is met with.

Nitrogen is present in fair quantity, but the content of organic matter is somewhat low.

Physically, the soil presents no striking differences from other members of the group. It is a light sandy loam in which the balance between sand and clay is well maintained.

PINNEY'S.

Pinney's estate is situated on the lower lands on the western coast of the island and about 1 mile north of Charlestown. Much of the land has for many years previously been in cultivation as a sugar estate.

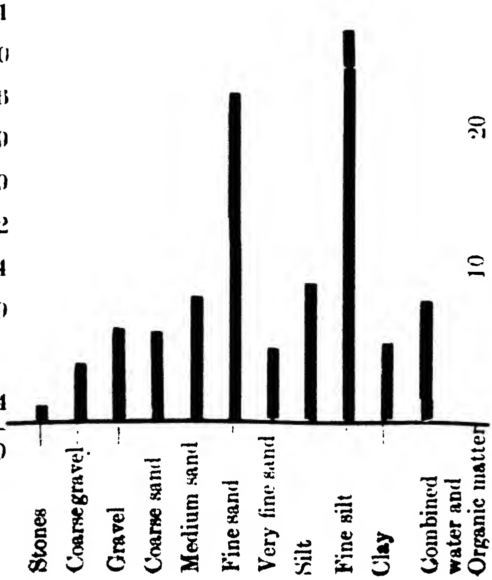
The field from which the sample was taken, is situated on the north-western side of the estate, near the coast, and 40 feet above sea-level.

CHEMICAL ANALYSIS.

Phosphoric acid soluble in citric acid solution	0·0054	per cent.
Potash ,, ,, ,, ,, ,,	0·0156	,, ,,
Carbon dioxide	0·020	,, ,,
Equal to carbonate of lime	0·046	,, ,,
Nitrogen	0·119	,,
Organic carbon	0·851	, .
Equal to humus	1·468	, ,

PHYSICAL COMPOSITION.

Stones	0·8
Coarse gravel ...	3·8
Gravel	6·1
Coarse sand ...	6·0
Medium sand ...	8·6
Fine sand ...	21·9
Very fine sand . .	4·9
Silt	9·2
Fine silt	25·4
Clay	4·9
Organic matter and combined water	7·4
	99·0



Agricultural clay	30·3
Water retained by water-free soil	

Chemically, the soil presents no features differing markedly from other Nevis soils.

The supply of potash is good, while that of available phosphate and carbonate of lime is again low. Nitrogen is present in fair amount, while organic carbon is low.

Physically the soil is another example of the typical, light sandy loams of Nevis. For the maintenance of tilth it is essential that the supply of organic carbon should be increased, otherwise the soil is liable to depreciate considerably.

SUMMARY.

Examination of the various grades of sand with the petrological microscope reveals the presence of minerals derivable from the andesites and hypersthene andesites which typically constitute the volcanic masses of these islands.

Typical hypersthene crystals are met with more or less abundantly in all samples, frequently together with brown hornblende, and green augite quartz is commonly present in variable amount ; as in the case of soils from other islands, this is probably of secondary origin. Magnetite, also, is usually present in moderate quantity. The felspars are mainly plagioclastic.

The foregoing series of analyses constitutes a moderately complete survey of the soils of Nevis.

A general survey of the soils examined, shows at once the close resemblance, both chemically and physically, which they present one to another.

As previously pointed out, the general physical configuration of the island, with its central volcanic cone sloping down more or less evenly on all sides to the sea, would lead one to expect that its soils would bear a closer resemblance one to another than is commonly met with in these islands. This expectation has been amply confirmed by examination. It is only to be expected that samples taken from certain localities would exhibit marked differences from the average, but these differences would be very localized, and in the selection of samples care has been taken to avoid apparent distortion of the true soil characteristics of the island.

Light sandy loams seem to be characteristic soils of the island.

The uniformly high percentage of available potash, and the very low percentage of available phosphate are remarkable and would appear to be characteristic of Nevis soils.

Available potash, which is derived from the weathering of the felspars in the parent volcanic rocks, is a constituent in which the volcanic soils of the Leeward Islands are almost invariably rich.

The chemical composition of the soil presents a close parallel to that of others already examined. Available potash is well supplied while phosphoric acid is deficient, and the usual deficiency of carbonate of lime is met with.

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Pinney's estate is situated on the lower lands on the western coast of the island and about 1 mile north of Charlestown. Much of the land has for many years previously been in cultivation as a sugar estate.

The field from which the sample was taken, is situated on the north-western side of the estate, near the coast, and 40 feet above sea-level.

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Equal to carbonate of lime	0·046	„ „
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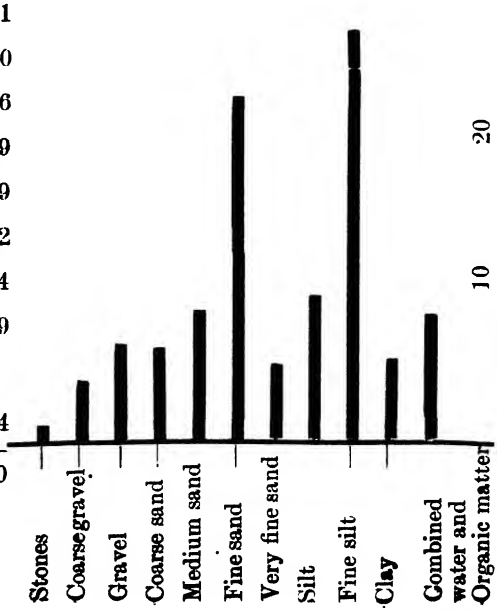
Organic carbon	0·851	, .
Equal to humus	1·468	, ,

PHYSICAL COMPOSITION.

Stones	0·8
Coarse gravel ...	3·8
Gravel	6·1
Coarse sand ...	6·0
Medium sand ...	8·6
Fine sand ...	21·9
Very fine sand ...	4·9
Silt	9·2
Fine silt	25·4
Clay	4·9
Organic matter and combined water	7·4
	99·0



Agricultural clay 30·3

Water retained by water-free soil

Chemically, the soil presents no features differing markedly from other Nevis soils.

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Typical hypersthene crystals are met with more or less abundantly in all samples, frequently together with brown hornblende, and green augite quartz is commonly present in variable amount; as in the case of soils from other islands, this is probably of secondary origin. Magnetite, also, is usually present in moderate quantity. The felspars are mainly plagioclastic.

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Available potash, which is derived from the weathering of the felspars in the parent volcanic rocks, is a constituent in which the volcanic soils of the Leeward Islands are almost invariably rich.

Available phosphate is, on the other hand, a much more variable quantity in the majority of the soils of other islands. The soils of Montserrat and Dominica do not exhibit a uniform deficiency in it, such as is shown by the soils of Nevis.

It is probable that, under some conditions, applications of phosphatic manures to the majority of Nevis soils, would prove markedly beneficial. Nevertheless the demands of certain tropical crops in this respect, notably cotton and sugar-cane, are, in our experience, so peculiar that caution in the use of manures of this class should be observed. Phosphatic manures would appear likely to be of marked benefit in the case of permanent crops such as cacao and limes, and may probably be useful in the case of cotton and sugar; this latter is however a matter for local experiment.

In common with all the volcanic soils in these islands, the soils of Nevis are invariably markedly deficient in carbonate of lime.

It is likely that in all cases, moderate dressings of lime, when combined with the liberal use of organic manures would prove of marked benefit, and we recommend its use at the rate of 2 to 8 cwt. to the acre.

It must, however, be borne in mind, that lime by itself is not a manure, and unless accompanied by an ample supply of manurial constituents, particularly by organic matter, is liable to result in ultimate impoverishment of soils.

For those estates near the sea, coral will provide an abundant and convenient source of lime, and such estates might easily find in sea-weed, a valuable source of supply of organic matter which might be used on the land with the lime.

The majority of the soils of Nevis are remarkable for the number of large stones and boulders that are distributed over their surfaces. Geological examination shows that they probably originated as volcanic ejecta. In any case, their very general distribution constitutes an important determining factor in the agricultural manipulation of these soils. It is probably not too much to say, that in many instances their presence is sufficient to remove from the possibility of cultivation 30 per cent. of the arable land in the fields in which they occur. From their large size it is impossible to give expression to the effect they exert, in the results of analysis quoted. Nevertheless in reviewing the characters of Nevis soils it is impossible to give an adequate account of their characters without taking full account of this characteristic and peculiar feature. Finally, attention must again be directed to the need for the free use of organic manures such as pen manures, and compost, and the growth of green dressings as an essential feature in the maintenance of tilth in these, in common with other tropical soils. In tropical agriculture all over the world the main problem to be contended with is the rapid decay of humus which takes place and the corresponding rapid decay of tilth likely to ensue in consequence. The combating of this tendency combined

with the conservation of soil moisture must, we are convinced, always be the chief end and object of cultivation in the tropics.

To sum up, the soils of Nevis are fertile and well adapted to the growth of all ordinary tropical crops, such as sugar-cane, cotton, and tobacco.

Localities with sufficient rainfall and adequate shelter should be capable of producing profitable crops of cacao and limes. The soils are deficient in phosphate and carbonate of lime, but with intelligent handling, the problem of the successful and remunerative growth of crops and the maintenance of tilth need present no special difficulties.

Thanks are due to Mr. R. H. Malone, and Mr. J. L. E. R. Lake, for assistance rendered in carrying out the physical analyses.

COTTON SELECTION IN THE LEEWARD ISLANDS, 1907-8.

BY FRANCIS WATTS, C.M.G., D.Sc., F.I.C., F.C.S.,

AND

H. A. TEMPANY, B.Sc., F.I.C., F.C.S.

Experiments in the selection of Sea Island cotton have been in progress in Antigua since 1905-6, when a series of selection experiments was inaugurated at the Skerrett's Experiment Station. During the following year the experiments were extended to co-operative work on estates in conjunction with the management, the original object with which they were designed being two-fold, namely: (1) to serve as demonstrations of the methods of cotton selection, (2) to endeavour to be the means of establishing strains of cotton suitable to the districts in which the estates are situated. Five years' experience with Sea Island cotton-growing in the West Indies has conclusively proved that the type of lint produced by the same batch of cotton seed is capable of being profoundly modified by the soil and climatic condition under which it is grown. This has been demonstrated by the great variations established in the types of lint produced in different West Indian islands, practically all of which were raised from the same importation of Rivers' seed in 1904. Hence the establishment of strains of seed suited to the localities in which they are destined to be grown is of importance, and this is especially so in an island like Antigua which presents wide divergencies in characters of soil and rainfall in different districts. A full account of the methods and results obtained in the earlier portions of the work has recently appeared in the *West Indian Bulletin*. It may however be of interest briefly to recapitulate them now.

A field selection is first of all performed, the best field being chosen for this purpose. In this field the best plants are then picked out, a systematic examination being made of each plant in the field. In judging the plants, the scheme follows that originally laid down by Mr. H. J. Webber of the United States Department of Agriculture, the points on which each plant is judged being as follows:—

Habit.

Height.

Number of bolls.

Maximum number of bolls per branch

Shape of bolls.

Size of bolls.

Distribution.

Resistance to disease.

To each of these points marks are assigned, the maximum for each point being ten, so that a numerical expression for the value of each plant is thus obtained. The type of plant aimed at is, to quote Mr. W. A. Orton of the United States Department of Agriculture, 'compact, 4 to 6 feet high, with a strong basal stalk and two to four well fruited basal branches. Fruiting branches should occur at close intervals, 1 to 2 inches, and a habit of double bearing or producing an auxiliary branch at each node should be developed. All branches should be close-jointed, and should bear a boll at every joint.'*

The lint from each of the plants selected in this way is picked separately and forwarded to the Government Laboratory for examination. In examining the lint, account is taken of (a) length and evenness, (b) strength, (c) proportion of lint, (d) fineness and lustre. In selecting lint at the present time, the property aimed at is not excessive but rather moderate length, i. e., $1\frac{3}{4}$-$1\frac{7}{8}$ inches, combined with evenness and strength, following the advice of Mr. A. H. Dixon, of the Fine Spinners' Association. (See *Agricultural News*, Vol. VI, pp. 97 and 102.)

The seed from plants which have satisfactorily passed both examinations is reserved for the planting of nursery plots on the estate on which the selection was made.

In 1906-7, this branch of the work was confined to Antigua, when, working in this way, five plants were selected in the field at Sion Hill estate, sixteen at Blubber Valley estate, and seven at Skerrett's Experiment Station. Of these, seed for planting were finally selected from two plants at Sion Hill, eight at Blubber Valley, and three at Skerrett's.

Nursery plots were established in this seed at Room's estate adjoining Sion Hill, in Sion Hill seed; at Blubber Valley and Orange Valley, in Blubber Valley seed; and at Skerrett's, in Skerrett's seed.

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* See *Farmer's Bulletin*, 302, United States Department of Agriculture 'Sea Island cotton: Its Culture, Improvement and Diseases,' by W. A. Orton.

In 1907-8, these experiments were extended to St. Kitt's and Montserrat. In November 1907, field selections were inaugurated in St. Kitt's by Mr F. R. Shepherd, acting in conjunction with the writer, and in Montserrat by Mr. W. Robson.

In Antigua in 1907-8, field selections were performed on Room's and Blubber Valley estates, and at the Skerrett's Experiment Station. In the former case the writer was responsible for the field selection, and in the two latter Mr. T. Jackson, Curator of the Botanic Station.

The selections were performed both from the nursery plots and from the best fields. At Room's, sixteen plants were selected, including two from the nursery plot established in pedigree Sion Hill seed from the year before. At Blubber Valley estate, thirteen plants were selected. Four of these were grown from pedigree seed sent to the estate from the Botanic Station, eight from plants growing in the nursery plots, and one from the general sowing of the estate. At Skerrett's the selection was confined to plants grown from individual seeds selected in the previous season.

In the Antigua series of experiments, as a result of the lint examination, seed from four plants was finally selected for replanting from the experiments at Room's, including both the plants selected from the nursery plots sown in Sion Hill pedigree seed--a fact pointing to the efficacy of the previous selection in this instance.

As a result of the examination of lint produced by the selected plants at Blubber Valley, only one plant was selected for replanting. It is of interest that this single plant was selected from one of the nursery plots sown with seed from the previous year's selection on the estate.

Without exception, the lint produced by the rejected plants was so weak as at once to rule them beyond the possibility of selection. Such a result as this, after two years' selection which involved considerable labour is, to say the least, depressing; but it would appear to be of considerable importance.

In every case the strength of the lint was a character upon which great stress was laid in selecting seed for planting. The seed therefore from which these plants were grown, was produced by plants which gave strong lint. In fact, the lint attached to and surrounding the seed which was planted, was strong, otherwise the seed would have been rejected.

With these facts in mind, we have to consider the reason why strong lint should produce in one generation a lint so weak as to be absolutely useless.

We are led to conclude from this, that strength of lint is not a character transmitted by means of seed, but that it 'depends largely on external conditions of environment. The abnormal weather conditions which prevailed during the growing season are probably the strongest of the external influences.

The result which was obtained at Blubber Valley is merely an exaggerated instance of what took place all over the island, or at any rate on the heavier clay and limestone soils, during the past season. This tendency toward weakness will in all probability always be exhibited in cotton grown on the heavy clay and limestone soils in seasons of abnormal rainfall.

It should be possible to combat this tendency to weakness in wets easons, to a certain extent, by selection ; and it is hoped that the single pedigree plant which has survived the ordeal of the last season at Blubber Valley, and produced a moderately strong lint, will be a starting point for a strain of cotton particularly suitable to the heavy soils and climatic conditions of that district.

In St. Kitt's twenty-seven plants were selected from the No. II manurial series of experiments with cotton growing on the La Guerite experiment plots, and eleven plants from cotton growing on Conaree estate.

In Montserrat cotton from twelve selected plants at the Botanic Station and six from Parson's estate was submitted for examination at the Government Laboratory, where the seed-cotton from all the selected plants was examined.

The details concerning the plants ultimately selected, and the character of the lint produced by them are given in Tables I and II.

TABLE I.

FIELD CHARACTERS OF SELECTED PLANTS. 1908.

ANTIGUA.

Character.	SKERRETT'S. (Marks given.)									YORKS.
	No. 3	No. 6	No. 9	No. 16	No. 17	No. 23	No. 24	No. 25	No. 42	No. 30
Habit	9	9	9	9	9	9	9	9	9	Somewhat irregular: 5 laterals.
Height	9	9	9	9	9	9	9	9	9	5′ 8″
Number of bolls ...	10	10	9	8	10	10	10	10	10	140
Maximum per branch	10	10	9	9	10	10	10	10	10	8
Shape of bolls ...	9	10	10	9	9	9	9	10	10	Fairly good
Size of bolls ...	9	10	10	9	9	9	10	10		Large
Distribution of bolls	10	10	10	9	9	10	10	10	10	Regular
Resistance to disease	10	10	9*	10	8*	10	10	10	10	Good
Total marks... ...	76	78	75	72	73	76	77	78	77	...

* Leaf blister-mite.

TABLE I.—(*Continued.*)

FIELD CHARACTERS OF SELECTED PLANTS, 1908.

ANTIGUA.

Character.	ROOM'S.							
	No. 5		No. 13		No. 14		No. 15	
	Marks	Remarks.	Marks.	Remarks.	Marks.	Remarks.	Marks.	Remarks.
Habit	...	...	8	1 lateral	10	...	10	10
Height	...	...	8	5′ 6″	10	4′	8	3′ 6″
Number of bolls	...	75	...	114	...	94	...	51
Maximum per branch	7	5	8	6	8	6	8	6
Shape of bolls	10	...	8	...	10	9	9	...
Size of bolls...	8	...	9	..	9	...	9	...
Distribution of bolls	..	..	9	...	9	...	9	...
Resistance to disease	...	...	10	...	10	..	9	...

TABLE I.—(*Continued.*)

FIELD CHARACTERS OF SELECTED PLANTS, 1908.

MONTSERRAT.

Character.	GROVE BOTANIC STATION.				PARSON'S.					
	No. 8		No. 9		No. 1		No. 4		No. 9	
	Marks.	Remarks.	Marks.	Remarks.	Marks.	Remarks.	Marks.	Remarks.	Marks.	Remarks.
Habit	10	5	10	5	9	1 large lateral	10	...	9	1 large lateral
Height	10	..	...	laterals	10	4′	7	3′	10	4′
Number of bolls	...	160	...	1 large branch 162	..	92	...	82	...	84
Maximum per branch ...	...	...	...	1	...	...	...	...	...	...
Shape of bolls...	...	...	...	...	...	...	...	...	...	...
Size of bolls	9	...	9	...	10	...	10	...	10	...
Distribution of bolls... ...	...	...	...	...	...	...	...	...	...	...
Resistance to disease	...	...	...	...	...	...	...	...	...	...

TABLE I.—(*Concluded.*)

FIELD CHARACTERS OF SELECTED PLANTS, 1908.

ST. KITT'S.

Character.	LA GUERITE.								CONAREE.	
	No. 8		No. 16		No. 20		No. 26		No. 111	
	Marks.	Remarks.	Marks.	Remarks.	Marks.	Remarks.	Marks.	Remarks	Marks.	Remarks.
Habit	9	1 large lateral	9	1 large lateral	8	...	10	...	8	2 laterals
Height	10	4′	10	4′	10	4′	10	4′	8	5′ 6″
Number of bolls	...	54	...	71	...	92	..	60	10	108
Maximum per branch ...	8	6	10	7	7	5	7	5	9	...
Shape of bolls	10	..	10	...	10	...	10	...	10	...
Size of bolls	10	...	10	...	10	...	10	...	8	...
Distribution of bolls ...	10	...	10	...	...	...	10	...	9	...
Resistance to disease ...	10	...	9	1 boll anthracnose	10	...	10	...	10	...

TABLE II.

COTTON SELECTION, ANTIGUA, 1908.

Skerrett's.

No. of Plant.	Length of staple, in millimetres.	Weight of seed-cotton per plant, in grammes.	Weak fibre. Per cent.	Lint. Per cent.	Fineness.	Lustre.
No. 3	Max. 49, Min. 46. Average 47·6.	343	22·3	28·1	10	10
No. 6	Max. 50, Min. 42. Average 46·5.	206	26·5	24·8	10	10
No. 9	Max. 48, Min. 45. Average 46·2.	209	28·0	26·3	10	10
No. 16	Max. 49, Min. 41. Average 45·1.	295·5	25·8	25·3	10	9
No. 17	Max. 50, Min. 38. Average 45·3.	180	25·1	30·2	10	10
No. 23	Max. 49, Min. 40. Average 45·4.	260	23·3	25·2	10	10
No. 24	Max. 47, Min. 45. Average 45·9.	232	22·7	30·8	10	10
No. 35	Max. 46, Min. 42. Average 44·9.	252	26·0	26·8	10	10
No. 42	Max. 48, Min. 41. Average 44·6.	170	27·3	24·7	10	10
York's.						
No. 30	Max. 48, Min. 44. Average 46·1.	30	22·2	25·7	10	8

TABLE II.—(*Continued.*)

COTTON SELECTION, ANTIGUA, 1908.

Room's.

No. of Plant.	Length of staple, in millimetres.	Weight of seed-cotton per plant, in grammes.	Weak fibre. Per cent.	Lint. Per cent.	Fineness.	Lustre.
No. 5	Max. 51, Min. 40. Average 47·0.	49	26·7	26·6	10	10
No. 13	Max. 49, Min. 44. Average 46·5.	71·5	18·7	28·1	9	9
No. 14	Max. 51, Min. 45. Average 48·5.	51	26·3	24·2	10	10
No. 15	Max. 46, Min. 42. Average 44·3.	61·5	17·1	29·7	10	10

COTTON SELECTION, ST. KITT'S, 1908.

La Guerite.

No. 8	Max. 50, Min. 42 Average 45·7.	58·6	20·5	28·5	10	10
No. 16	Max. 48, Min. 40. Average 44·3.	73·5	13·7	26·8	10	10
No. 20	Max. 51. Min. 43. Average 47·0.	83·8	20·2	27·7	10	10
No. 26	Max. 48, Min. 44. Average 45·4.	71·7	25·5	29·6	10	10
Conaree.						
No. 111	Max. 48, Min. 40. Average 45·7	92·0	24·0	24·7	10	10

TABLE II.—(*Concluded.*)

COTTON SELECTION, MONTSERRAT, 1908.

Grove Botanic Station.

No. of Plant.	Length of staple, in millimetres.	Weight of seed-cotton per plant, in grammes.	Weak fibre. Per cent.	Lint. Per cent.	Fineness.	Lustre.
No. 8	Max. 50, Min. 45. Average 48·2.	340	17·9	25·1	10	10
No 9	Max. 47, Min. 45. Average 45·6.	315	28·2	24·3	10	10
Parson's.						
No. 1	Max. 51, Min. 49. Average 50·2.	216	23·4	27·0	10	10
No. 4	Max. 49, Min. 45. Average 46·9.	121	22·5	24·3	10	10
No. 9	Max. 50, Min. 45. Average 48·6.	189	17·0	24·1	10	10

As a result of the experiments in St. Kitt's, four plants were finally selected at La Guerite and one at Conaree.

The general type of St. Kitt's cotton was markedly short in staple, though very strong on the whole. The whole of the cottons rejected from the St. Kitt's experiments were discarded on this account.

Of the Montserrat cottons, five were finally selected for replanting. It must however be mentioned, that of the eighteen cottons submitted for examination, nine were lost.

The Montserrat cottons, on the whole, presented the most favourable all-round features during the past season, for, though not so strong as the St. Kitt's cottons, they far surpassed them in length, and possessed adequate strength.

At Skerrtte's Experiment Station, forty-three lots of seed cotton were examined. These were produced from plants grown from seed selected on account of the length of the attached lint. The method in which the selection was performed was described fully in the *West Indian Bulletin*, Vol. IX, pp. 215-34.

Briefly, the method followed was to determine the length of lint attached to individual seeds, and to select those which conformed to certain standards.

Seeds selected in this way were graded according to four types, which were as follows:—

Type 1—Length 50-55 mm. (i. e., over 2 inches), and even in character.

Type 1 *a*—Length 50-55 mm. (i. e., over 2 inches), and particularly even in length.

Type 2—Length 45-49 mm. (i. e., 1¾ to 2 inches), and even in character.

Type 2 *a*—Length 45-49 mm. (i. e., 1¾ to 2 inches), and particularly even in character.

The forty-three lots of seed-cotton examined, were derived from seed of these types as follows:—

Thirteen lots of seed-cotton were grown from seed of type 1, three lots from seed of type 1 a, twenty lots from seed of type 2, and seven lots from seed of type 2 a.

As a result of examination of these forty-three lots of seed-cotton, it was only found possible to retain nine lots for future planting. In the majority of instances, while the cottons on the average were satisfactory as regards length, everywhere there was displayed an objectionable tendency to weakness and wastiness. It is probable that, as in the case of other cottons, this was due in a measure to the bad seasonal conditions experienced.

In Table III are given the average length of staple of the various lots of cotton examined, together with a statement of the type of seed from which it was derived.

It will be seen that types 2 and 2 *a* of seed have yielded an average lint of precisely the same length as types 1 and 4, viz., 44·9 mm.

It would therefore appear that separation of the specially long types of lint in the selection of seeds sown, at any rate in this particular instance, has had no effect on the character of the lint reaped.

On the other hand, it is worthy of note that of the nine lots of seed finally selected for planting, seven were derived from types 2 and 2 a, and two only from type 1; the lint reaped from seeds of types 1 and 1 a being weaker than that of types 2 and 2 a.

It would appear probable, therefore, as a result of two years' experimentation in this direction, that in the case of seeds having lint over 50 mm., selection on account of the length of the attached lint is not likely, when dealing with the types of cotton handled so far, to lead to the growth of similar lint in the offspring.

It is regarded as likely that seeds of this type owe their greatly increased length to intensification due to local influence, and that in the offspring the lint produced will revert, as far as concerns length, to the average produced by seed of this class. Moreover, this intensification in the parent seed may be liable to induce weakness in other directions in the offspring.

TABLE III.

Parent.	Type of lint attached to parent seed.	Average length of lint reaped. in millimetres.	Parent.	Type of lint attached to parent seed.	Average length of lint reaped, in millimetres.
1	Type 2	42·6	28	Type 1	43·4
2	„ 2a	42·4	29	„ 1a	47·2
3	„ 2	47·6	30	„ 1	45·0
4	„ 2a	46·4	31	„ 1	47·4
5	„ 2	45·4	32	„ 1	...
6	„ 2a	46·5	33	„ 1a	42·0
7	„ 2	46·3	34	„ 1	44·9
8	„ 2	45·4	35	„ 1a	...
9	„ 2	46·2	36	„ 1	43·6
10	„ 2a	...	37	„ 1	45·2
11	„ 2	...	38	„ 1	43·4
12	„ 2a	...	39	„ 1	44·7
13	„ 2	45·9	40	„ 1	48·5
14	„ 2	43·6	41	„ 1	44·6
15	„ 2	47·5	42	„ 1	...
16	„ 2a	45·1	43	„ 1	44·5
17	„ 2	45·3			
18	„ 2a	43·8	Average length of lint reaped from types 1 and 1 a.		44·9 mm.
19	„ 2	41·6			
20	„ 2	45·4			
21	„ 2	42·8			
22	„ 2	47·0			
23	„ 2	45·4			
24	„ 2	45·9			
25	„ 2	42·8			
26	„ 2	42·6			
27	„ 2	45·7			
Average length of lint reaped from types 2 and 2 a.		44·9 mm.			

In the case of seeds bearing lint of from 45 to 49 mm. in length, this does not differ greatly from the average intrinsic length of the class of cottons handled, as the offspring lint would consequently bear a closer resemblance to the lint of the parent seed.

In short, it would appear likely that the length of the lint produced is a function of the parent plant which it transmits as a whole to its offspring, the differing length of the lint attached to individual seeds bearing only a secondary relation to the length of lint of the offspring.

In order to elucidate this, a further series of experiments is again being carried out during the present season on seeds divided into types in similar fashion to the above, in Antigua St. Kitt's, and Montserrat.

Of the lots of seed-cotton finally selected during the past season at Skerrett's, Nos. 2, 17, 23, and 21 were established in nursery plots at Skerrett's, while Nos. 6, 9, 16, 35, and 42 were distributed to planters for careful trial on estates.

A quantity of seed-cotton grown from plots established in selected seed of the previous year at the Botanic Station was also distributed to planters. This seed originated from plants Nos. 203, 206, and 207 of the 1906 selection.

At the present time, several estates possess small fields established in strains of seed raised from single plants selected in the 1906 experiments. In the majority of instances, these appear to be producing strains of cotton superior to the average met with in the island at the present time.

To sum up, during the past year, cotton selection experiments have been continued in Antigua, and inaugurated in St. Kitt's, and Montserrat.

In Antigua the work has been carried on under difficulties owing to seasonal conditions, the effect of the weather having been to eliminate many of the selections made in previous years, thereby entailing loss of labour.

It is obvious that differing conditions in different islands lead to the production of distinctive types of cotton in each case, and it is necessary, in order that the best results may be arrived at, that strains of seed suited to local conditions should be established. In effecting this end, selection work of this description must be of the highest importance.

Much credit is due to all who have taken part in the work of the selection of cotton in the field and in the laboratory. The work has been carefully done by all the officers of the Department, and every facility has been rendered by those in charge of the estates where trials have been carried on.

THE GROWTH OF LEGUMINOUS CROPS AND SOIL INOCULATION.

BY W. BIFFEN, B. Sc.

The fact that the growth of leguminous crops, as peas, beans, clover, etc., instead of diminishing the fertility of the land, often resulted in an increase of its crop-yielding capacity, was known and acted upon by practical workers in agriculture from early times, although it is only within comparatively recent years that any reason was brought forward which accounts satisfactorily for the matter.

In the eighteenth. and greater part of the nineteenth centuries. while leguminous crops were frequently included in farm rotations in European countries, opinions differed as to the actual way in which these plants were able to make such good growth—often without the aid of any nitrogenous manure—and at the same time to leave the land in such a condition that highly satisfactory returns were obtained from a succeeding cereal crop. By many it was thought that this was explained by the deep-rooting habit of the legumes, which enabled them to tap resources of moisture and food in lower strata of the soil, untouched by other plants. Liebig, a well-known agricultural chemist, brought forward the theory that clover and other broad-leaved plants were able to obtain considerable supplies of nitrogen from the air, this nitrogen being absorbed not in the elementary state, but in the form of ammonia and other compounds, which exist in small quantity in the atmosphere.

The means by which plants obtain the nitrogen necessary for their growth, and the proportion between the quantity of nitrogen supplied in the manure and that removed in the resulting crop, were investigated by Boussingault, a French experimenter. about the middle of the nineteenth century. Boussingault weighed and analysed the crops produced on his own farm during six separate courses of rotation (all of which included a legume crop). As a result, he found that, on the whole, from one-third to one-half more nitrogen was removed in the produce than was supplied in the manure. He further observed that the excess of nitrogen in the crop over that provided in the fertilizer was especially great in the case of a leguminous crop. This naturally pointed to the conclusion that the known value of clover, peas, and other plants of this family, was due to a power possessed by them of enriching the soil with nitrogen obtained from some outside source, most probably the air.

Further experiments carried out by Boussingault, however, and also experimental work conducted by Lawes and Gilbert at Rothamsted in England, not only with legumes, but with plants of other families as well, failed to substantiate the growing belief that the free nitrogen of the atmosphere was available as food for growing plants of any family. As a result, the matter rested for a time, until new investigations

carried on in Europe and America, re-opened the question, and about the year 1883 evidence was brought forward which was sufficient to prove that plants of the legume family, under certain conditions, are capable of utilizing the free nitrogen of the air as a source of food supply.

Among the many investigators of this question were two Germans, Messrs. Hellriegel and Wilfarth, to whom belong the credit of clearing up the whole matter of nitrogen assimilation by leguminous plants. In experiments conducted by these two scientists, the medium of cultivation employed consisted of sterile sand, in which were planted the seeds of plants belonging to different botanical families. The necessary plant food was supplied in the form of nutrient solutions. Mineral plant food was given in all cases, but it was observed that when combined nitrogen was withheld, all the seedlings of plants belonging to orders other than the Leguminosae died from starvation as soon as the nitrogen contained in the seed was used up. By far the greater number of the legumes (peas) grown, died at the same stage, but it was noted that one or two pea seedlings recovered and made good growth, despite the absence of combined nitrogen. In such cases, examination always showed that the roots of the plant were set with little nodules, which, it was known, are generally characteristic of the growth of legumes under normal conditions in the field. No nodules could be found on the roots of the plants which died. A further series of experiments was then started, in which pea plants, grown in sterile sand, were all fed with solutions of mineral plant food, but to some were added, in addition, just at the stage when the seedlings were dying of nitrogen hunger, small quantities of a watery extract of ordinary fertile soil. As a result, the young plants so treated recovered and grew to maturity, their roots in every case developing nodules similar to those already referred to.

Hellriegel and Wilfarth were, therefore, bound to conclude that the power possessed by peas and other leguminous plants of appropriating free nitrogen from the air, and utilizing it in building up their own tissues, was dependent upon the formation of nodules upon the roots of these plants. The experiments in which the addition of watery extracts of fertile soil resulted in the revival and renewed growth of the seedlings previously dying from nitrogen starvation, led further to the belief that the nodules themselves were due to inoculation of the soil—and hence of the roots of the plants—with some species of micro-organism. Other investigators, notably Lawes and Gilbert, confirmed the work of Hellriegel and Wilfarth, the results of which were published in 1886. A further step in advance was made by Beyerinck, who demonstrated that the root nodules on leguminous plants were full of bacteria, which could be cultivated also on various artificial media. Beyerinck gave the name *Pseudomonas radicicola* to the bacteria in question.

The *Pseudomonas* bacteria appear to be widely distributed in most fertile soils, although they naturally exist in much greater quantity in land on which legume crops are frequently

grown. The organisms, as grown in artificial non-nitrogenous culture media, are observed to be exceedingly minute in size, rod-shaped, and generally in rapid motion. They exist free in the soil in this form, and enter the host plant through the root hairs, forming tubercles or nodules on the younger rootlets only. Within the nodules, however, the bacteria frequently undergo considerable modification, and in different plants they assume rather large rod- or Y-shaped forms. The irregular forms are especially numerous in the older tubercles. At the same time they increase enormously in number.

The investigations carried out, as described above, enabled a conclusion to be finally reached which afforded a satisfactory explanation of the observed facts, and of the contrary results which had at different times been obtained in experiments on the matter. It was evident that the bacteria in the root nodules were the agency by which leguminous plants were enabled to assimilate nitrogen from the air, and that, in the absence of these organisms, peas, clover, etc., were as dependent upon the supply of combined nitrogen in the soil as plants of other botanic families, e.g., sugar-cane, cotton, etc. Since the relationship of the nitrogen-assimilating bacteria to the legume cannot be regarded as in any way parasitic, but is rather a physiological partnership of mutual advantage, the term *symbiosis* (literally 'living together') has been applied to describe it. The plant supplies the necessary carbohydrate material which the bacteria require for their life purposes, and the micro-organism in turn gathers from the air nitrogen which is ultimately utilized by the legume plant. It may here be mentioned that the mechanism of the actual process by which the plant avails itself of the nitrogen compounds elaborated by the micro-organisms is still incompletely understood. It is possible that the host plant may attack and absorb the highly nitrogenous bacteria, or, on the other hand, it may avail itself of the soluble and diffusible substances formed within the bacterial cell. The latter appears the more probable explanation, since before the plant could utilize the nitrogenous compounds forming the substance of the bacterial organisms, it would be necessary that the latter be first broken down and dissolved. They would, in fact, have to be brought into a condition in which the plant could absorb them as food, by a process analogous to that in which the insoluble food supply in seeds is dissolved for the benefit of the developing embryo on the germination of the seed. This process of solution is effected by means of various ferments or enzymes, but, so far, no proteolytic ferment (i.e., one capable of dissolving proteid or nitrogen compounds) has been discovered in leguminous plants, and therefore there is little basis for assuming that these plants secure the nitrogen collected by the bacteria in their root nodules by dissolving and absorbing the latter.

The figures which have been placed on record showing the actual amounts of nitrogen added to a soil, as the result of growing various leguminous crops, are useful as giving a clear idea of the value of including such crops in farm and estate rotations. Even in the course of a single season these quantities of nitrogen may be quite large. Experiments with velvet beans

in Alabama showed a gain of nitrogen amounting to 213 lb. per acre, while with the same crop, gains of 172 lb. and 141 lb. per acre were obtained in Louisiana and Florida respectively. Trials with cowpeas have shown equally satisfactory results. A publication of the U. S. Department of Agriculture mentions that in a very large number of experiments with various legume crops carried on in sixteen States, a gain of 122 lb. of nitrogen per acre was indicated. At the Delaware Experiment Station, a crop of crimson clover was found to have added as much as 200 lb. of nitrogen per acre to the soil in one season. Cowpeas are not infrequently grown in rotation with cotton in some of the cotton-growing districts of the Southern States of America. An instance reported by the Alabama Experiment Station indicates the beneficial influence of the legume crop on the succeeding crop of cotton. In this case there was noted an increase of 696 lb. in the yield of seed-cotton to the acre, or 83 per cent., as the result of ploughing under a crop of cowpea vines on land which had been in cotton in the previous season.

The annals of the Rothamsted Experiment Station contain many illustrations in point. Thus an experiment is recorded in which a piece of land, which in the previous five years had grown cereal crops without nitrogenous manure, was divided into two parts in 1872, one being sown with barley and the second with clover. Barley was again grown on the first plot in 1873, but the clover was allowed to stand, three cuttings being made for fodder purposes during the season. The quantities of nitrogen in the crops from the two plots were 37·3 lb. in the barley yield, and 151·3 in the clover. An analysis of the soil was made after the crops had been removed, which showed a content of 0·1566 per cent. of nitrogen in the first 9 inches from the surface in the plot where clover had been grown for two seasons, as compared with a nitrogen content of 0·1416 per cent. on the other portion. In 1874, barley was once more grown on both plots, the quantity of nitrogen removed in the barley following barley being 39·1 lb., while in the barley following clover 69·4 lb. were removed.

Another experiment was carried out on land which at the start contained 2,657 lb. of nitrogen per acre in the first 9 inches from the surface. Barley and clover were grown in 1883, and clover only in 1884 and 1885. It was estimated that 319·5 lb. of nitrogen was removed in the crops cut during the three years, but a soil analysis made at the end, showed that nitrogen equal to 2,832 lb. was present in the top 9 inches, or a gain of 175 lb. per acre in the three years, making a total, with the crop removed, of nearly 500 lb. of nitrogen per acre to be accounted for. The work, therefore, done by this partnership between leguminous plants and the nodule-producing bactereia is of the utmost importance, and must annually add to the wealth of the world many hundreds of thousands of pounds sterling.

With the facts already enumerated before them, it was natural that workers in agricultural science should begin to debate the question whether the majority of cultivated soils

were sufficiently well stocked with nitrogen-gathering bacteria to give the best results when a leguminous crop was grown, or whether, by theintroduction into soils oft he suitable organisms. and the more extended growth of legumes, considerable increase in crop yields could not be obtained. A great deal of experimental work in relation to this subject has been done in the past twenty-three years.

In work of the nature referred to, it is obvious that the main point is to ensure the presence of the assimilating bacteria in the soil under experiment. This can be done by distributing over the land, and slightly harrowing in, a supply of soil taken from a field which has just previously yielded a flourishing crop of the legume to be grown. As early as 1887 soil inoculation experiments of this kind were undertaken by Salfeld at the Moor Culture Experiment Station, Bremen, Germany. The trials were made with such legumes as lupins, serradella, clover and beans, on reclaimed peaty and sandy soils, on which, without inoculation, such crops made but little growth, and developed no root nodules. About 3½ cwt. of suitable soil were distributed per acre over the land. and harrowed in before sowing the seed. The results of Salfeld's work were strikingly successful. As the season advanced, the effect of the inoculation was markedly evident in the dark-green colour and luxuriant growth of the plants, on the land which had been treated as described, as compared with the land where no soil had been scattered, which bore very small yellow plants that ultimately died of nitrogen hunger.

Salfeld's results were received with great interest, and the example thus set was shortly followed by a number of investigators working with many different kinds of soils. A satisfactory measure of success was achieved in some instances, but many cases were recorded in which the results were negative, and the opinions entertained as to the practical value of soil inoculation were of a very contradictory nature. On sandy heath soils, on moorland recently placed under cultivation, and on raw soils brought up from deeper layers by the plough, the operations had undoubtedly been proved to be highly beneficial, but on the majority of cultivated soils, it was not evident that inoculation had been attended with any benefit.

With the extension of experiments similar to those of Salfeld, one or two disadvantages connected with this method of soil inoculation began to make themselves felt. The transport of large quantities of soil from one district to another was naturally expensive. Injurious fungi, together with weed seeds, might be introduced into the soil, with the desirable bacteria. These considerations, combined with the fact that the nitrogen-assimilating organisms could be isolated from the root nodules of legumes, and cultivated on various artificial media, led to greater attention being paid to the possibilities of inoculation with pure cultures of the *Pseudomonas* bacteria, and in the past twelve years or so, a number of preparations, all containing this organism, have been brought forward for soil inoculation purposes.

In this connexion there arises a question which is obviously of considerable importance in influencing the success of any

effort at soil inoculation, but which has not yet been definitely settled. This question relates to the identity of the various bacteria which are found living in association with different species of Leguminosae. Much investigation has been done with the object of ascertaining whether all the organisms living in symbiosis with various agricultural leguminous crops are identical with *Pseudomonas radicicola*, first isolated by Beyerinck from pea plants, whether the different kinds are varieties of this species, or whether there are different species associated with particular plants. Colonies of bacteria cultivated from root nodules from different species of legume show many points of similarity, but also some points of difference. In early experiments carried out by Hellriegel, it was seen that a watery extract of soil on which clover and beans had been grown was instrumental in inducing nodule formation on clover and bean seedlings grown in sterile sand, but had no effect whatever on serradella and lupin plants growing under the same conditions. When an extract from a sandy soil which had just previously borne the latter plants was added, however, the serradella and lupins formed nodules on their roots and grew apace. Hellriegel therefore concluded that there were essential differences between the bacteria from the various legumes. The evidence that has since been brought forward seems to point to the view that all the bacteria inhabiting the root tubercles of leguminous plants, which are the agency of nitrogen assimilation from the air, belong to the species *Pseudomonas radicicola*, but that if this organism is grown for some time continuously in association with one kind of plant only, it becomes so modified as to be specially adapted to give the best results with this species alone, and loses its efficiency in greater or less degree for all other kinds of legumes. Experiments conducted by Nobbe and Hiltner prove that the best results from inoculation can only be expected when the crop grown is inoculated with bacteria from the same species of plant.

As already mentioned, pure cultures of the root nodule bacteria had been prepared on various artificial media, and in 1896, two Germans, Messrs. Nobbe and Hiltner, developed this idea on a commercial scale. Cultures of the organisms, grown on a gelatine medium, were started by infection from root tubercles from the different leguminous plants cultivated as field crops, and this preparation was placed on the market contained in small glass bottles, under the name 'Nitragin.' In using the nitragin for inoculation purposes, the nutrient jelly was to be dissolved in a quantity of lukewarm water, and the solution sprinkled over the seed, thorough distribution of the bacteria being ensured by this means. The seed was then to be dried before planting.

The merits of nitragin were thoroughly tested at experiment stations and on private farms both in Europe and America. It was hoped that the preparation would supply not only nitrogen-gathering bacteria to soils lacking these organisms, but bacteria of a high degree of efficiency. Although

in the first two seasons a few favourable reports on the results obtained from the use of nitragin were received, by far the greater majority of the returns sent in were of a negative character, and briefly, it may be stated that the preparation turned out to be a distinct failure. It seemed after all that the pure culture method of inoculation, from which so much had been expected, was less reliable than the older plan of introducing the nitrogen-gathering organisms by distributing a supply of fertile earth from fields that had lately borne flourishing legume crops.

Despite the unsatisfactory results which followed the first attempt to establish the use of pure cultures of *Pseudomonas radicicola* as the standard means of inoculation, the matter still continued to receive a good deal of attention. On further investigation it was concluded that the chief reason which accounted for the failure was the unsatisfactory nature of the medium (gelatine) upon which the bacteria had been grown. Gelatine differs essentially from the media in which the bacteria normally live, i.e., the soil and plant cell, principally in that it is of animal origin, and contains large quantities of nitrogen. With the provision of abundant nitrogen at hand, the bacteria are discouraged from utilizing the free supply of the air, deteriorate rapidly, and either die out altogether, or lose, wholly or in part, their power of fixing atmospheric nitrogen.

There was another point which had been overlooked in designing the method of inoculation described, but which later investigation indicated had helped to prevent the full success of the inoculation efforts. During the preliminary process of germination, seeds excrete certain soluble substances which have a detrimental effect upon the vitality of the assimilating bacteria, and, as a consequence, the organisms are unable properly to infect the legumes, unless some special steps are taken to neutralize the poisonous effects of the excretions mentioned. It was found subsequently, that the latter could be made harmless to the seed by adding to the water in which the cultures were prepared, a small quantity of certain soluble salts, or of skimmed milk.

These points being recognized, other culture media, notably agar jelly (which is prepared from a kind of sea-weed, and contains practically no nitrogen) were tried, and these efforts were attended with a greater measure of success. In Bavaria, for instance, during the year 1903, ninety-eight inoculation experiments were carried out with Hiltner's agar nitragin. Of these, eighty-one were favourable, nine negative, and eight doubtful—a remarkably good result, since in some cases, increased yields followed inoculation even on soils that had already borne good crops of the corresponding legume. Nobbe and Hiltner also employed various liquid preparations as culture media in which to grow the bacteria, and these were found to be better adapted to maintain the vitality of the organisms for a longer time than agar jelly and other solid media.

Hellriegel and Wilfarth's discoveries, and the results of Lawe and Gilbert's work at Rothamsted excited considerable attention in the United States, and extended investigations on the results of inoculation with different species of legume plants were started in that country. At first. the method employed was that of inoculation by means of earth from other legume fields. The two crops which appeared to benefit most by this practice were the soy bean and alfalfa. In the case of clover, cowpeas, field peas, beans, and vetches, the organisms responsible for nodule formation and assimilation of nitrogen appeared to be already present in most cultivated soils, and these crops gave good returns, and did not apparently require inoculation.

At a later stage the United States Department of Agriculture turned its attention to the subject of artificial cultures of *Pseudomonas radicicola* for inoculation purposes. Dr. G. T. Moore, of the Bureau of Plant Industry, undertook the work, and devised the method of preparing the cultures. Moore's method differed somewhat from that of Nobbe and Hiltner. The American scientist first prepared an active culture of the nodule-bacteria in a liquid medium, the composition of which included little or no nitrogen, in order that the assimilating power of the organisms might be increased. Absorbent cotton was then dipped in the liquid culture, and subsequently dried rapidly at a low temperature. In this condition they retained a number of the bacteria, and formed a convenient medium for transmitting the organisms, and for starting new liquid cultures. With the cotton was sent out, in every case, a packet containing suitable quantities of cane sugar, potassium phosphate, ammonium phosphate, and magnesium sulphate, which were to be dissolved in a large bulk of water thus forming a nutrient solution in which the bacteria multiplied rapidly under favourable conditions when the cotton culture was added. The seed to be inoculated was placed in this solution for a time, being afterwards dried before sowing.

Moore's cultures were very extensively tried by the United States Department of Agriculture, in co-operation with working farmers all over the country during the year 1901. To everyone who made application, a free packet of inoculating material was supplied, with detailed instructions as to the method of using it. In this way about 12,500 tests were made under the most varied conditions.

With the arrival of reports on the results of all these trials, it soon appeared, however, that the general measure of success which had followed inoculation with Moore's cultures was far below what had been anticipated. It exhibits, indeed, little superiority in its influence upon the crop yield to that shown by the original nitragin preparation of Nobbe and Hiltner. Although in a very considerable number of cases, small increases of crop followed inoculation, yet the general verdict from the American experiment stations, and also from European stations where Moore's cultures had been tried, was that these preparations were inefficient. The advantages of inoculation by means of pure cultures were obvious in

theory, but the ideal pure culture, the use of which would cause these advantages to appear in practice, had yet to be devised.

Investigation carried out with the object of ascertaining the cause of these disappointing results showed that the method of preserving the bacteria in a dried form on cotton was not so satisfactory as had been supposed. Many of the organisms perish during the process of drying, and any considerable change in temperature and moisture conditions that may take place previous to the use of the culture has a detrimental effect upon the vitality of the bacteria that still remain. By Moore's method, too, the actual preparation of the culture solutions with which the legume seed was to be treated before sowing, had to be carried out by the farmers themselves, who would hardly be likely to work under the careful and exact conditions that would be followed in the laboratory. Under ordinary farm circumstances, the risk of contamination by the introduction of foreign bacteria, moulds, and yeasts, from the air, from water, or by means of the utensils employed, was at its maximum, and many of the introduced organisms might be instrumental in preventing the growth and multiplication of the nitrogen-gathering bacteria of the cotton culture.

Culture preparations for inoculation of leguminous crops are still sent out by the United States Department of Agriculture, but as a result of the difficulties that have been experienced, the use of absorbent cotton has been abandoned, and the medium employed, consists of nitrogen-free liquid put up in hermetically sealed bottles. Numbers of different cultures are prepared, which correspond to the different legume crops cultivated, each culture being adapted to give the best results with a particular species. Thus cowpea cultures, alfalfa cultures, clover cultures, etc., are all obtainable. The directions that accompany each bottle warn the recipient to utilize the material within ten days or two weeks, as otherwise deterioration may set in, which will render the culture useless.

Nearly two years ago Professor Bottomley, F.R.S., of London, turned his attention to the subject of soil inoculation, and as the outcome of his investigations, he brought forward another pure culture preparation, somewhat similar to that of Moore, to which the name 'Nitro bacterine' was given. 'Nitrobacterine' was described by the originator as a 'powder preparation of the bacteria.' It was sent out in sealed packets containing cotton wool, as in the early American method, but the medium also contained in addition a number of dry, earth-like particles. With these packets were sent also small quantities of soluble nutritive substances, to be dissolved in water, and the culture solution was prepared and utilized in a manner similar to that already described in the case of Moore's cotton cultures. The importance of using pure water that had been boiled and allowed to cool, perfectly clean utensils, and of taking every precaution to protect the solution from contamination was emphasized by Professor Bottomley. Those testing nitrobacterine were advised that inoculation might also be effected by 'watering' the young legume plants with the culture solution.

It may be added that Professor Bottomley did not confine his attention to leguminous plants alone in this connexion. He also brought forward other culture preparations which he hoped might be instrumental in enabling cultivated plants belonging to certain other natural orders to draw upon the stores of atmospheric nitrogen for food purposes.

The results so far reported with nitro-bacterine have not been of such a nature as to indicate that this preparation is in any way superior as an inoculating material to Nobbe and Hiltner's nitragin or Moore's cotton cultures. In the summer of 1908, some experiments with Professor Bottomley's culture material were conducted with garden peas at the Wisley Gardens of the Royal Horticultural Society. These are reported upon in detail in the *Journal* of the Society for November last (Vol. XXXIV, part 2), and a summary of the results was given in a late number of the *Agricultural News* (Vol. VIII, p. 62). These results were of a purely negative character, and the closing paragraph of the report is as follows: 'It is concluded that the inoculation of leguminous crops with "nitro-bacterine' in *ordinary garden soils* is not likely to prove beneficial.'

During the year 1908, the effect of inoculation on the returns given by various leguminous crops was tried at Antigua and at Grenada. In the former island where cowpeas, woolly pyrol, and alfalfa were the crops in connexion with which the investigations were made, nitro-bacterine was the inoculating material employed. Experiments were conducted at the Experiment Station, and also on estates, the property of Messrs. Henckell, Du Buisson & Co., at the instance of the owners. At Grenada, cowpeas formed the crop under test, and a liquid culture preparation, obtained from the United States Department of Agriculture was employed. The effect of inoculating sugar-cane plants with the material forwarded by Professor Bottomley for that purpose was also tried both at Antigua and Barbados.

At Antigua the nitro-bacterine culture solutions were prepared at the Government Laboratory, and it is remarked in the report on the results of the experiments, that satisfactory growth of the culture took place in the case of every package. Seed of the different legumes under trial was also inoculated at the Laboratory and portions of the culture solution were afterwards distributed to the centres where the experiments were to be made, for inoculation of growing crops, and of the soil. Where crop and soil inoculation was carried out, two inoculations were made, at an interval of a fortnight.

Cowpeas were grown under experiment at Cassada Garden and at Fitches' Creek, and the effects of inoculation both by immersion of the seed in the culture solution before sowing, and of 'watering' the soil with the solution after sowing were tried. In no instance did inoculation have any influence in increasing the crop yield, however. Indeed, the highest return at Cassada Garden was given by the plot sown with seed that had not been inoculated, and which was not watered with the culture solution.

It is to be presumed (as Mr. Tempany states in his report that the soil was well stocked with the bacteria responsible for nodule formation on this particular crop, or that the soil was well supplied with available nitrogen. Examination of the roots of inoculated and untreated plants showed that though, on the whole, there appeared to be slightly more nodules on the roots of the inoculated plants than on those which had received no treatment, the difference was not very marked.

Experiments with woolly pyrol were conducted at the Experiment Station, and at Fitches' Creek, Cassada Garden, and Gambles estates, the experiment plots being ⅛ acre in area in every case. It is interesting to note that, in the case of one estate at least (Cassada Garden), the results of inoculation with this crop were more definite and satisfactory. From the control plot, which received no inoculation, 330 ℔. of green bush were gathered. A second plot, sown with uninoculated seed, but the soil of which later received applications of the culture fluid, yielded 700 ℔. of bush: a third plot that had been sown with inoculated seed, but received no further treatment, gave a return of 970 ℔. of green bush, while from the fourth plot - sown with inoculated seed and also 'watered' with the culture fluid 1,015 ℔. of bush were reaped. The results for two plot experiments at Gambles estate are also reported, and in these also, although to a lesser degree, the beneficial effects of inoculation are observable. From the untreated plot, 30 ℔. of green bush were reaped, while 50 ℔. of green bush were obtained from the plot sown with seed that had been inoculated. It may be added that a good number of nodules were present on the roots of all the plants examined, but it is stated that no marked differences as to number could be observed on the inoculated and the uninoculated plants.

At Fitches' creek and the Experiment Station no results were obtained, since the woolly pyrol plants were destroyed by caterpillars. A scheme of inoculation experiments with cowpeas was carried out in 1908 at Grenada at the Botanic Station and on six estates. These experiments were designed to answer two questions: (1) whether any benefit is to be derived from inoculation of leguminous crops such as cowpeas on Grenada soils, and (2) whether, by inoculation, leguminous green dressings such as cowpeas can be grown under the shade produced by mature cacao trees. With the object of deciding the first question, two plots, each ¼-acre in area, were sown with cowpeas, at the several centres, one plot being planted with inoculated, and the other with uninoculated seed. To investigate the possibility of growing leguminous crops under shade, plots of 1 acre in extent, covered with full-grown cacao trees, were planted with inoculated cowpea seed.

In regard to this latter question, the results obtained at all seven centres were of the same nature, and indicated that inoculation had no effect in encouraging the growth of the cowpeas when planted beneath the cacao. The amount of shade varied from fairly light to very dense, but in no case did the peas do more than produce one or two leaves, and they soon died, showing all the symptoms of lack of sufficient light.

Varying results were obtained on the cowpea plots in the open. At the Botanic Station, and on two of the estates, the returns showed no difference whatever in favour of inoculation. At two other estates the returns from the inoculated plots were slightly superior to those which had not been treated. Finally, at the two remaining estates, Dougaldston and Diamond, the reports state that the inoculated areas gave yields considerably higher than the untreated plots. No actual figures as to the weights of produce reaped are given, but it is mentioned that on Diamond estate, the plants on the inoculated plot were about one-fourth as large again as on the uninoculated land.

Reference has been made to Professor Bottomley's culture preparation for inoculating sugar-cane plants. It may be added that a number of cane plants were inoculated at Antigua and Barbados in accordance with the directions supplied, but that in no case could inoculation be observed to have any effect whatever.

From the facts which have been enumerated, it will be seen that the history of past attempts at soil inoculation by artificial cultures, forms a record chiefly of failures, although numerous instances have been reported in which a certain measure of success has resulted. The failures which have been recorded cannot be regarded as indicating that the operation is in itself valueless, since the importance of ensuring that the nitrogen-gathering organisms are present in the soil is obvious. But it is evident that the earlier and more enthusiastic advocates of the process formed an exaggerated idea of the advantages which they believed would in general follow soil inoculation, and later researches have enabled a truer estimate to be formed of the conditions and circumstances under which the process is likely to be followed by beneficial results. It was at one time hoped and even claimed, that inoculation of any soil on which a leguminous crop was to be grown, would undoubtedly lead to a satisfactory increase in its crop-yielding capacity. Experimental results soon showed the fallacy of this belief, and indicated that the advantages of the process are not general, but may be expected only under certain limited conditions. Briefly stated, the conditions under which inoculation may be expected to prove distinctly advantageous are on virgin soils newly brought under cultivation, on reclaimed peat lands, and also on cultivated farm lands when the leguminous crop to be planted has not previously been grown in the neighbourhood, and on the soil in question. For inoculation to have its full effect, these soils must be properly drained, and contain suitable proportions of lime, phosphates, and potash. But in the majority of cases it would appear that the process is not capable of increasing to any appreciable extent the crop-yielding capacity of most cultivated farm and estate lands, more especially if ordinary leguminous crops have been regularly included in the rotations followed. This is due to the fact that the nitrogen-fixing bacteria which the culture preparations are designed to introduce, are already present in the great bulk of such soils, and inoculation can only

prove of benefit if the organisms introduced are more efficient (their 'efficiency' being measured by the quantity of nitrogen fixed) than those already present in the soil.

Reference has been made to the question of the possibility of increasing the amount of nitrogen-fixation by cultivating and introducing into the soil races of bacteria superior in vigour to those which already exist there. This is a phase of the subject of soil inoculation which has of late years received a good deal of attention. It has been found that the capacity of the *Pseudomonas* organisms to assimilate nitrogen is not fixed and unalterable, but that this power varies with changed conditions of growth. Under certain conditions they are liable to lose their power of fixing nitrogen, while at the same time retaining the capacity to multiply at a rapid rate. From this consideration it will be seen that the number of nodules on the roots of the legumes in association with which the bacteria live, does not always form a basis from which deductions can be made as to the amount of nitrogen fixed. The bacteria may lose their power of fixing nitrogen as the result of cultivation on unsuitable media, such as gelatine, among other causes.

A German investigator, Suchting, found that the amount of nitrogen assimilated by legumes varied with the source of the bacteria, whether these were derived from the soil, from crushed nodules, or from cultures grown on suitable media. He reports that the efficiency of the last was greater than that of the other two, while the organisms direct from the crushed nodules were superior to those in a watery extract of the soil. Similarly his experiments confirmed the observation. that the most 'efficient' races of *Pseudomonas radicicola*, when grown upon unsuitable media, rapidly lost their power of nitrogen-fixation, without diminishing their power of multiplication. The source of the infecting organisms, and the manner in which they have been propagated, are evidently, therefore, matters of considerable importance.

Future researches may result in the production of improved cultures of high nitrogen-fixing power, the bacteria of which are capable of maintaining themselves in the soil against the kindred organisms already present there; but, as pointed out by Mr. A. D. Hall, in the latest edition of his book 'The Soil,' it must be borne in mind that even if such improved races of the nodule-forming bacteria can be introduced to the plant, the improvement they can produce in the crop yield is likely to be something of the order of a 10-per cent. increase, a gain which is only really perceptible after careful and continued experiments, and one not to be detected by the eye of the ordinary farmer or planter. This appears to be the most that can be expected from soil inoculation, on most farm and estate lands that have been long under cultivation.

As indicated, however, there is no doubt that, under certain circumstances, inoculation forms a valuable addition to the means possessed by the agriculturist of adding to the fertility of the land, and the conditions which indicate that the process is likely to be attended with distinct advantage, have already been indicated. When land has been recently reclaimed from the heath or bog state, it usually happens that

none of the *Pseudomonas* organisms are present. Liming is required in such cases, and on such lands it will be found that the effects of inoculation on the growth of a leguminous crop are of a very different order from those brought about on ordinary cultivated lands. It is quite usual to observe that the introduction of the appropiate organisms into the soil will change a stunted, sickly looking growth into a vigorous and profitable crop. The extension of the cultivation of a legume crop, such as alfalfa, cowpeas, etc., into a new district, forms another occasion when inoculation has been found to be valuable, and even necessary.

In this connexion, since it is a practical instance in point, it is worth while to refer to the useful work that has been done in reclaiming and making fit for cultivation, large tracts of barren, sandy land in East Prussia. The scheme for this work was devised and carried out by Dr. Schultz, of Lupitz, and the agency employed by him to reclaim the land consisted of growing lupins and ploughing in the green crop. Mineral manures, chiefly basic slag and kainit, were applied to the soil.. The lupins store up nitrogen from the air, and thus there is gradually built up a store of humus which is not only a source of plant food, but is also of great importance from the physical point of view, in binding together the loose sand and making it retentive of moisture. On these waste lands, which in many cases had not carried any leguminous vegetation whatever, soil inoculation has proved a most valuable aid, and the process was indeed necessary to the success of Dr. Schultz's scheme. The increase in fertility of the land is indicated by the fact that the soil of a field growing lupins every year from 1865 was, in 1880, found to contain 0·087 per cent. of nitrogen in the surface 8 inches, as compared with 0·027 in an adjoining pasture. As the result of the continuance of the scheme mentioned for eleven more years, the proportion of nitrogen had, by 1891, increased to 0·177 per cent., despite the annual removal of the lupin crop, and the fact that the manuring had been with phosphates and potash only.

In regard to present views on methods of soil inoculation, the failure which so frequently attended the use of pure cultures in the past has caused their employment to be regarded with a certain amount of distrust, and in Europe and America the tendency among agriculturists has of late been to place more reliance on the original if somewhat cumbersome legume earth method. There is yet a good deal to be learned in regard to this matter, and the subject is under investigation in a number of laboratories. It is possible that in the future a practical and satisfactory method of inoculation by means of pure cultures may be evolved.

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CENTRAL FACTORIES.*

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The subject of Central Factories for sugar-making in Barbados has been discussed for many years, and settled conclusions appear difficult to arrive at. At the present moment, the question again occupies public attention, and it is probable that a discussion of facts by this Society will prove useful in throwing light on a local problem of some difficulty.

The question is one which may be approached from many sides, and which presents many aspects. Perhaps I may be able to-day to present to you some aspects which have hitherto not been very fully considered.

Briefly stated, the arguments in favour of the introduction of modern factories are:—

That the mills of large factories are capable of obtaining a much greater quantity of juice from the canes and of producing a better class of sugar, which may be stored and handled without loss: whereas the small mills of muscovado factories are said to be inefficient, and the sugar produced is of lower grade, not in ready demand, and is liable to loss in handling and storing.

* Read at a meeting of the Barbados Agricultural Society, May 28, 1909.

The arguments on the other side are :—

That the cost of the machinery necessary to effect the improvement absorbs a large portion of the profits; that while the existing system produces a lower grade of sugar, it produces also a high grade of molasses for which a good price can be obtained, and that in the aggregate, the muscovado process pays as well as the modern factory process.

The argument obviously turns first on the amount of juice expressed from the canes by modern mills as compared with small mills. Now, here at the outset, difficulties arise in regard to the comparison of the work done by different mills on different kinds of canes; for it is clear that the quantity of juice which can be crushed from a cane depends on the quantity that it contains, and planters know well that the amount of juice contained in canes varies considerably. Hence we learn very little when we are told that one mill is giving 68 per cent. of juice and another 57½ per cent. Under some conditions the mill giving the lower figure may really be doing the better work.

Our ideas concerning the composition of canes and the amount of juice which it is possible to obtain from them may be rendered much clearer by a very simple formula, which, although not perfectly accurate, affords approximations which are sufficiently near for our purpose. The quantity of juice contained in a cane may be calculated approximately thus :— From 100 deduct one and one-third times the percentage of fibre in the cane. On this assumption we obtain the following :—

Canes which contain	would contain
10 per cent. of fibre	86·7 per cent. of juice
11 " " " "	85·3 " " " "
12 " " " "	84·0 " " " "
13 " " " "	82·7 " " " "
14 " " " "	81·3 " " " "
15 " " " "	80·0 " " " "
16 " " " "	78·7 " " " "
17 " " " "	77·3 " " " "

Following on this, we have a most useful suggestion formulated by Mr. J. Lely, Chemist to the Antigua Sugar Factory Company, namely, that the efficiency of the work done by a mill may be measured by ascertaining, in the megass coming from the mill, the quantity of juice carried away by 100 parts of fibre. (See *West Indian Bulletin*, Vol. IX, p. 85.)

A number of experiments have demonstrated that the ordinary three-roller mill leaves in the megass from 150 to 180 parts of juice per 100 of fibre, or even more if very poor work is being done. The megass from a single mill with a cane splitter contains about 120 to 130. That coming from a train of mills consisting of a Krajewski cane crusher and two 3-roller mills, in which maceration is effected, contains from 65 to 70; while the megass coming from a train of mills consisting of a Krajewski cane crusher and three 3-roller mills employing maceration may be reduced to a content of 25 to 30 parts of juice to 100 parts of fibre.

If we tabulate the results which may be obtained from various systems of milling as effected on canes of different fibre contents, we obtain interesting results:—

Type of milling plant.	Juice per 100 of fibre in megass.	Juice extracted per 100 of cane when fibre content of cane is:—				
		10 per cent.	12 per cent.	14 per cent	15 per cent.	16 per cent.
Bad single mill ...	200	66·7	60·0	53·3	50·0	46·7
Fair " " ...	180	68·7	62·4	56·1	53·0	49·9
Good " " ...	150	71·7	66·0	60·3	57·7	54·7
Cane splitter and single mill ...	130	73·7	68·4	63·1	60·5	57·9
Krajewski and two 3-roller mills with maceration	70	79·7	75·6	71·5	69·5	67·7
Krajewski and three 3-roller mills with maceration	30	83·7	80·4	77·1	75·5	73·9
Krajewski and three 3-roller mills with maceration, best work	25	84·2	81·0	77·8	76·2	74·7
Total juice in cane	...	86·7	84·0	81·3	80·0	78·7

Such a table enables us to realize at once the enormous influence exerted by the fibre of the cane upon the quantity of juice which is obtainable. Thus, a good single mill will obtain from 71·7 to 54·7 per cent. of juice according as the cane contains from 10 to 16 per cent. of fibre. The table also enables us to see at a glance the influence on the crushing, of the perfection or imperfection of the mills employed.

This table shows the futility of judging the character of the mill work solely on the basis of the percentage of juice obtained. It shows also how many of the conflicting statements concerning mills which have puzzled us in the past may have arisen.

The question at once arises: 'What quantity of fibre may we expect to find in our own canes'? The amount of fibre in the canes dealt with at the Antigua Sugar Factory averages somewhat over 15 per cent.; we are without accurate data for the fibre content of whole crops in Barbados, but I believe the

amount will lie in the neighbourhood of from 14 to 15 per cent. This being so, we should expect the single mills of Barbados to have crushing records ranging from 53 to 60 per cent.; and these figures, I believe, correspond fairly well with actual observations.

In this connexion, it must be remembered that the work of the mill must be measured by its average performance during the whole crop, taking into account all defects arising from the steam or wind power, bad feeding, and such like. What a mill *can* do may be very different from what it actually does on the average.

Let us turn now from the extraction of juice from the canes to the extraction of sugar from the juice. Experience has shown that in a modern factory 88 to 89 lb. of sugar of 96° polarization are sent to market for every 100 lb. entering the factory in the juice, whereas under the muscovado system about 76 lb. of sugar of 89° polarization are produced. In the case of the muscovado system about 90 wine gallons of molasses are produced for each ton of sugar, while in the modern factory about 30 wine gallons of low grade molasses are produced. That is, about 3·05 wine gallons of muscovado molasses and 1·02 wine gallons of 'factory' molasses for every 100 lb. of sugar in the juice.

Calculating on the basis of the foregoing figures we find that if a factory (as at Antigua) working on canes of a fibre content of 15 per cent. requires 9·15 tons of cane to make a ton of crystals, a muscovado factory with the same canes and a mill giving megass containing 180 of juice per 100 of fibre will require 13·9 tons of cane to produce a ton of muscovado sugar. Should the mill give megass containing 150 of juice per 100 of fibre, the canes required will be 12·8 tons per ton of sugar.

In order to show the influence of the fibre in the canes and of the working of the mill on the number of tons of cane required to make a ton of sugar, the following table has been prepared :—

Assuming that the juice contains 1·95 lb. of sucrose per gallon.

Kind of mill.	Tons of cane required to make 1 ton of sugar when fibre content is :—		
	14 per cent.	15 per cent.	16 per cent.
Muscovado,			
Bad single mill	13·66	14·56	15·60
Fair „ „	12·98	13·74	14·60
Good „ „	12·08	12·62	13·31
Factory (Crystals), Double crushing and Krajewski	8·80	9·05	9·29

All these figures justify the general conclusion, that under conditions where 13½ tons of canes are required to make a ton of muscovado sugar, a ton of crystals can be made in a modern factory from 9 tons of canes: if the canes dealt with are of such a quality that more or less is required in one case, a corresponding amount more or less will be required in the other.

We are now brought to the point arrived at in a recent report of a Committee of the Legislature, and may accept the monetary statements put forward in the appendix to that report.

These calculations, as given in Appendix A of that renort are as follows:—

Muscovado System.

Thirteen and one-half tons of canes are estimated to produce 1 ton 89° muscovado sugar and 90 wine gallons of molasses. The value of the canes is estimated thus, when muscovado sugar is worth:—

	$2·12 per 100 lb. £	s.	d.	*$1·80 per 100 lb.* £	s.	d.
1 ton 89° muscovado	9	17	10	8	8	0
90 wine gallons molasses at 13½c.*	2	10	8	2	10	8
Puncheon		16	8		16	8
The value of produce is	13	5	2	11	15	4
But the cost of manufacture (exclusive of renewals of machinery, say, 4*s.* per ton of cane) is	2	14	0	2	14	0
So that the value of 13½ tons cane without provision for upkeep of machinery, etc., is	10	11	2	9	1	4
And the value of 1 ton of cane is		15	7½		13	5

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*With molasses at 16c. per gallon add 2½c. per gallon, i.e., 2½ x 90 gallons = $2·25 or 9*s.* 4*d.* as increased value of molasses from 13½ tons of cane, i.e., per ton of cane		8½		8½
The value of 1 ton of cane is increased to	16	4	14	1½

Factory System.

Thirteen and one-half tons of cane will produce $1\frac{1}{2}$ tons of 96° dark crystals and say 36 imperial gallons of molasses. The value of the canes will be as follows, when 96° dark crystals are worth :—

	$2·57 per 100 lb. £	s.	d.	$2·25 per 100 lb. £	s.	d.
$1\frac{1}{2}$ tons of 96° dark crystals ...	18	0	0	15	15	0
36 imperial† gallons molasses at 6c.		9	0		9	0
The value of the produce is ...	18	9	0	16	4	0
But the cost of manufacture of $1\frac{1}{2}$ tons is	4	2	6	4	2	6
So that the value of $13\frac{1}{2}$ tons cane (without provision for purchase and renewal of machinery and buildings) is...	14	16	6	12	1	6
And the value of 1 ton cane is ...	1	1	$2\frac{1}{2}$	0	17	$10\frac{1}{2}$

The increased value of canes in the factory system is between 5*s.* 7*d.* and 4*s.* $5\frac{1}{2}$*d.* per ton, which represents the sum available by means of which to procure a factory. This difference is reduced to 4*s.* $10\frac{1}{2}$*d.* and 3*s.* 9*d.* if molasses sells at 16c.

To the figures given in that report, I have added the calculations showing the position when the price of sugar is at a lower level, and also the statement showing the effect of the high price sometimes obtainable for molasses. The calculations there given take no account of the sum required for the purchase and upkeep of the machinery under either system. Under the muscovado system the machinery and buildings already exist and have been paid for; the cost of their upkeep and renewal alone has to be taken into account. It is estimated that this is equal to about 13*s.* 6*d.* per ton of sugar or 1*s.* per ton of canes. The cost of ordinary renewals necessary to keep the factory machinery in good order has been included in the 55*s.* per ton allowed for manufacture.

The sum required to purchase a modern factory will depend to a considerable extent on its size, and may range from £15 per ton of output for a 3,000-tons factory to £11 or £12 per ton for one of 5,000 tons capacity.

It seems reasonable to suppose that a sum equal to about 12 per cent. should, over a period of twelve or fifteen years, be sufficient to pay interest and sinking fund on the capital and create a small reserve fund. This would constitute a charge of from 3*s.* to 4*s.* per ton of cane, as against the 1*s.* per ton

† One hundred imperial gallons equal to 120 wine gallons. To change imperial to wine gallons add one-fifth. To change wine to imperial gallons deduct one-sixth.

estimated under the muscovado system. The direct gains to be expected from a factory may therefore be taken to be equal to 1 or 2*s*. per ton of cane, pending the time that the capital is paid off, and after that they may be some 3*s*. or 5*s*. per ton.

These figures show that there is much truth in the argument that the cost of the machinery absorbs a very large proportion of the estimated gains. It must, however, be remembered that the cost includes a charge for sinking fund, so that under favourable circumstances it is estimated that the capital would be repaid in about fifteen years, when the heavy charge for interest and sinking fund would cease. The figures also show that the success of a factory must largely depend on the obtaining of capital at reasonable rates and they go far to support the idea that the factory must be on a co-operative basis, whereby the cane growers can obtain the ultimate advantages to be derived when the capital is paid off.

For the sake of convenience and easy calculation, the estimated gains under a factory system have been reckoned on the basis of a ton of canes: there is some danger lest the statements of the results on the basis of so small a unit may create the impression that the probable gains are trifling or negligible. That this is not the case may be better appreciated perhaps if these probable gains are re-stated in terms based on the ton of sugar or on the crop of an estate.

The estimated gain of a shilling or 2*s*. per ton of cane means an estimated gain of 13*s*. 6*d*. to 27*s*. per ton of sugar as now made; or, for a small estate making 100 tons, an estimated gain of from £62 to £135, while after the repayment of the capital the gains may rise to something like £2 to £4 per ton of sugar now made, or £200 to £400 on a small estate now making 100 tons of muscovado sugar.

Apart from the consideration whether it is desirable to substitute modern factory methods for muscovado methods in order to increase the profits of the industry, there remains the much more important question whether we may not be driven to make the change in order to *preserve* the sugar industry.

We are told from time to time that the demand for muscovado sugar for refining purposes is steadily declining, and the evidence appears to point strongly in that direction. The value of 96° dark crystal sugar may be taken as the standard of values in the raw sugar market; the true state of the market may usually be measured by the changes shown in connexion with this class of sugar. The nominal difference in value between 89° muscovado and 96° crystals in bond is about 26c. per 100 lb., but it rarely happens that muscovado brings a price (in bond at the port of entry) only 26c. below that of 96° crystals: the difference is frequently from 40c. to 50c. below that of crystals, and this may be taken as the measure of the refiner's reluctance to purchase. It appears to me that it would be wise to ascertain in an authoritative manner, what is the true attitude of the refiner towards muscovado sugar. If it is clear that there is likely to be a steady demand for some years at prices about 28*s*. to 38*s*. per ton

below the price of crystals, and the price of sugar remains near what it is to-day, the position may not be a very grave one. My impression is that muscovado sugar will become less and less in demand for refining purposes, and that the value in relation to crystals will fall lower than it is to-day. This may be regarded as a personal opinion, but it is one which it may be well to check by well-directed inquiry. I may point out that large Canadian refiners have expressed to me their reluctance to handle muscovado sugar, and they appear to have impressed the same view upon Mr. Fielding, the Canadian Minister of Finance, judging from his remarks in his recent budget speech.

It is claimed that the position of the muscovado industry may be improved by devoting attention to the manufacture of syrup. I question whether the gains from making syrup are so great as some are disposed to think. My estimate of the position is somewhat as follows: If one converts into syrup the juice which would make 2,000 lb. of muscovado sugar and 90 wine gallons of molasses, one will obtain about 315 to 320 gallons of syrup. Deducting the molasses which would have resulted in any case, we find that 2,000 lb. of muscovado sugar are equivalent to 225 to 230 gallons of syrup, and we may construct the following table:—

Value of 100 lb. muscovado sugar.	*Value of 1 wine gallon syrup.*
\$1·60	13·9c. to 14·2c.
1·70	14·8c. „ 15·1c.
1·80	15·7c. „ 16·0c.
1·90	16·5c. „ 16·9c.
2·00	17·4c. „ 17·8c.

The gains due to making syrup will be the difference between the market price of syrup and that shown in the table. It must be stated that no account has been taken of any possible profit on the puncheon.

I am not closely familiar with the trade in syrup, but from what I gather, the prices paid for syrup do not greatly exceed the value of the equivalent of muscovado sugar, and I question if large profits are made by its manufacture.

Little or nothing would be gained in stability in connexion with the muscovado industry by making less sugar and more syrup, for syrup can be made with ease in large factories should the price warrant such a practice. The moment, therefore, that the syrup trade becomes a highly profitable one, it will be captured by the large factories.

The position with regard to molasses is somewhat different. Muscovado molasses is not likely to be made in large factories, though even this would be possible if high prices held out sufficient inducement. It does not appear likely, however, that the price of molasses can at any time become very high relatively to the price of sugar: should it do so, syrup will be substituted or sugar will be used. Still the fact remains that the muscovado industry depends largely upon molasses, so that future action will be mainly influenced by the market for molasses.

Let us now consider the increased stability and improvement of position induced by the production of crystal sugar in large factories.

The sugar produced by a factory is of uniform quality, and is in regular demand by refiners. There is therefore a ready market for it in many countries. The sugar is of a quality that will keep and is not subject to loss by draining. It can thus be readily stored and shipped upon advantageous terms. These qualities enable the vendors to secure the best market and take advantage of favourable prices offered in any particular market in a manner which is difficult with muscovado sugar. This is calculated to give stability to the industry, which is lacking under a muscovado system; the want of stability, to my mind, constituting a grave danger to the industry.

The increased value of the output from a given quantity of canes may be taken at something like 35 to 40 per cent. There is thus some 35 per cent. more money in circulation under a factory system, and trade is proportionately increased. It is true that some of this increase is in the form of interest on capital, but paying investments are good means of establishing a country's credit and increasing its trade.

It is a mistake to imagine that a factory system owes its success to a reduction in employment and a cutting down of wages: it owes its success to the utilization of what would otherwise be waste, and it gives employment to an increased number of skilled workers engaged in effecting this recovery. The salaries and wages' bills of a factory are larger than the corresponding bills of small muscovado works, but the increased payments are derived from the recovery of sugar wasted in the latter and so benefiting no one.

All these points tend to an increase in general trade, with the concomitant advantages of greater general prosperity and an improved revenue.

Other contingent advantages of a system of factories should not be overlooked. Such a system affords an opportunity for remunerative employment as engineers, as sugar-makers, and as skilled workers in other directions for some of our young men who now tend to migrate to larger places: while good factories will in themselves constitute educational centres where young men may be trained and so aid in no small degree in elevating the general level of industrial skill as regards the island generally.

The ability to deal promptly and regularly with the canes as they are reaped, coupled with the relief from the anxieties of sugar manufacture should re-act upon the agricultural aspect of the industry. Cultural operations should be facilitated, because the crops should be reaped in good time and operations which are now imperfectly performed would receive adequate attention. The fact that all the canes would be weighed would enable planters to learn with precision the advantages to be gained by the various systems of cultivating and manuring which are practised, while the introduction of

the best varieties of canes would be hastened by the precise knowledge which would be arrived at as to the economic value of each kind.

Generally, then, both agricultural and mechanical arts would be appreciably stimulated to the considerable advantage of the sugar industry and those connected with it.

One of the most important objections which I have heard raised in opposition to a change from a muscovado to a factory system is that such a change will profoundly disturb the economic basis on which agriculture in Barbados is founded, in that it will destroy the somewhat small sugar estates and substitute large ones. Now, it appears to me that there need be no fear on this head, for the factory system preserves the independence of the small proprietor and strengthens his position. The fact that the small proprietor sells canes instead of sugar and molasses does not weaken his independence, it rather strengthens it, for it relieves him of much work, much expense, and much anxiety. A man with 20 acres of canes may make as good a bargain for their sale to a factory as a man with 200. Opportunity to sell to a factory strengthens his position. So far from a factory system undermining the independence of the small estate owner, it appears calculated to strengthen it and to permit of the economic working of small holdings in a manner which is quite out of the question if every proprietor is to be saddled with the manufacture of his own sugar.

Little has been said concerning some of the peculiar drawbacks incidental to the muscovado system, but I may remind you that it sometimes happens that sugar is produced which has a lower test than 89°, and is consequently penalized—a misfortune which has not been taken into account with the foregoing calculations. Wet weather, absence of wind, shortness of fuel, all give rise to difficulties which would be removed by a factory system, but the losses arriving from these causes have not been taken into account: their removal may be placed amongst the gains to be looked for from the change to a factory system of working.

The question of making sugar in modern factories, under conditions quite similar to those obtaining here, has in recent years been placed on a definite and satisfactory footing by the successful working of such a factory in Antigua. The information necessary for the formation of a sound opinion as to the applicability of this system to the circumstances of Barbados may now be readily obtained, and the moment seems opportune for a careful consideration of the whole question.

You may rest assured that competition in connexion with sugar will grow keener and keener, and the severity of the struggle will be felt season after season in Barbados. The position may be improved while the credit of the country is good, but should adverse circumstances or aggressive competition weaken that credit, the opportunity may be lost.

The time has now arrived when the United States produce within their own territories practically all the sugar they

need; they therefore cease to come into the world's markets. We may soon even have to contemplate the possibility of the United States having to export any surplus of sugar.

Recent events point to the increased attention likely to be given to the production of beet sugar in Canada, and doubtless, in the near future this will have a marked bearing on Canadian imports.

With all this, West Indian sugar will be forced into more and more direct competition with European beet sugar, and with cane-sugar from the East, including Java and Mauritius

If improvements are to be instituted, their inception should be carefully considered now, while the muscovado industry is in a fairly stable condition and possesses good credit. Waiting until the industry promises to be less profitable, or unprofitable, implies waiting until a time when capital will be more difficult to obtain, and waiting perhaps until a time when the industry is moribund and efforts at improvement may come too late.

THE UNDERGROUND SYSTEM OF THE SUGAR-CANE.

BY GILBERT G. AUCHINLECK, B.Sc.,

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Everyone who is familiar with the cultivation of the sugar-cane knows that it is usually propagated by cuttings from a mature stem, and that each cutting, being composed of only a few nodes, can have but two or three buds or 'eyes' ready to develop into new stems. In spite of this a single cutting will in the course of a season give rise to a large clump of canes, and the question at once arises as to how this occurs. Such a question can be solved only by an examination of the underground system, in order to ascertain the origin of the numerous shoots continually arising. No examination of the kind, so far as is known to the writer, has ever been made, possibly because it involves the tedious operation of removing the network of roots which masks the structure. A description of this hitherto neglected part of the botany of the sugar-cane may therefore be of interest.

When a clump of well-grown canes is taken up, its behaviour on handling leads one to the conclusion that the various stems are closely connected to one another: they cannot readily be separated, and there is a rigidity about the underground parts which forces one to think that the union between the stems is more than a mere entanglement of roots. On shaving away the mass of roots with a razor or sharp knife the nature of the union becomes apparent, and it is seen that there is a definite organic connexion with interesting and important characteristics. This organic connexion is of the nature of a rhizome, that is, a horizontal underground stem,

with nodes and internodes, and possessing the power of sending out shoots from its buds—a structure deserving a detailed description.

The rhizomes of the sugar-cane are short, often pear-shaped structures with very short internodes and an immense supply of roots; they are capable of growth when severed from the parent, being in every way similar to the rhizomes of other plants belonging to the class of monocotyledons, such as ginger, cannas, the bamboo, and cardamom. The buds are very regularly arranged, being alternate, one to each node, and remaining latent until subjected to favourable conditions, when they develop into rhizomes similar to the parent. The tip of the rhizome under ordinary cultivations will grow upwards into a green aerial shoot. As a young rhizome may contain as many as six or eight internodes for every inch of its length, and as each internode bears a bud, it can readily be understood how a large clump of canes may arise from the growth of one 'eye' of a cutting. Another important feature of rhizomes in general is that they contain a large store of plant food as nourishment for their young shoots, and so injury to the older parts does not necessarily destroy the younger growing tips. Such a structure is of particular value for tiding the plant over any climatic period, such as winter, in which the aerial parts are destroyed.

In the West Indies, after the mature canes which spring from the plant cuttings have been reaped, a second growth is allowed to ripen, and this is known as 'ratoons'. The process can be continued season after season, giving rise to first, second, and third ratoons, and from this practice an idea has originated that each new upgrowth is a direct result of cutting back the preceding set of old stems, looking on the growth of ratoons as entirely parallel to the production of new shoots caused by pruning a dicotyledon. That the two cases are in no way similar may be seen by considering the life-history of the sugar-cane.

When bamboo (*Bambusa* sp.), sugar-cane (*Saccharum officinarum*), or cardamom (*Elettaria* sp.) flowers, the culms which bear the flower panicles die back, and it has been proved in India that even if the flower panicles be removed, the bamboo culms still die, showing that the flowering is the result of the dying, and not vice versa. This being the case, it is unlikely that the young ratoon shoots of the sugar-cane should be merely lateral buds from the base of the mature stem, as the latter is foredoomed to an early death and would be incapable of shooting afresh after cutting back. The stems of the ratoons spring from the tips of the rhizomes, and a glance at the accompanying figure shows that the real sugar-cane plant from a botanical point of view, has its habitat underground, and that the aerial culms merely support the necessary leaves and flowers. Below ground the plant is permanent and everlasting; above ground it lives but for a season, and it is with this fact in his mind that the botanist should consider the cane if a clear understanding of the terms 'stool' and 'ratoon' is to be arrived at.

The accompaning sketch was made from a stool which had just yielded a crop of first ratoons, and it. affords several points of interest. The lowest structure from which, directly or indirectly, all the other parts have sprung is an eye of the original cutting or plant cane, and so may be designated a 'primary bud'. Presumably its tip should have developed into an aerial shoot and have been reaped as a first ratoon, but it was injured and so the ratoon crop consisted of no buds of an earlier order than secondary ones. They all sprang from the eyes of a primary bud, and similarly we find that

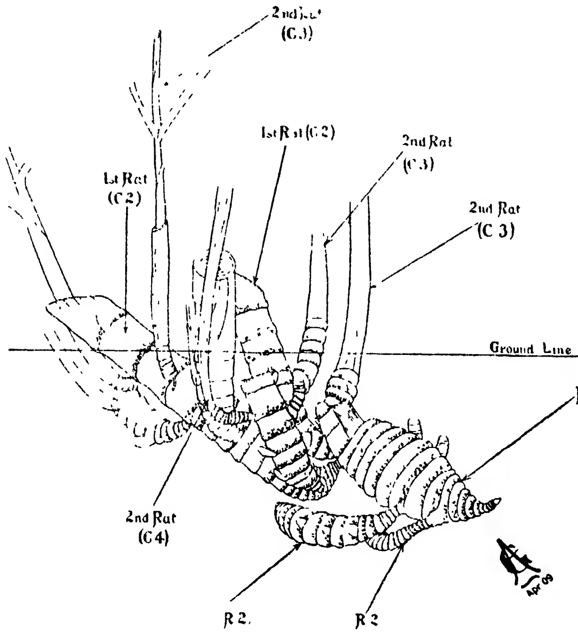

Fig. 10. Stool of the Sugar-cane. (*Original.*)
R1. Primary rhizome from plant cane. R2. Secondary rhizome.
C1. Primary culm. C2. Secondary culm.

several of the future second ratoons are in reality buds of the third or even fourth order. We can thus lay down as a general rule, the fact that the degree (First, Second, etc.) of any ratoon is not necessarily the same as the degree of the bud (primary, secondary, etc.) of which it is the development. The expression 'first ratoon', is simply a popular term to describe the stems which happen to be ripe for reaping two seasons after cuttings have been planted.

In order to demonstrate clearly the idea of the habit of the sugar-cane which is outlined in the foregoing. statements, a comparison of the growth of a bamboo clump with that of a stool of canes will be found useful One is surprised to find that they are exactly similar. Each is essentially the endless and continuous development underground of buds which give rise to rhizomes and aerial stems, the former repeating the process, and the

latter holding their leaves up to the sun, flowering, and then dying back; and so the clump or stool extends month after month, never dying, and having no definite resting period between each upgrowth of culms. If for any reason we reaped mature bamboo stems, we should have the same deceptive appearance of separate plant and ratoon growths, with a resting period between them, as we have in the sugar-cane. Our regular and periodic reapings of the cane have given us the false idea that each upgrowth is complete and definite in its beginning and ending. Without doubt the cutting of one crop tends to hasten the growth of the next, but a stool of neglected canes in its growth would differ in no way from a stool of bamboos.

All the facts given above tend to alter considerably the ordinary notion of the habit and life-history of the sugar-cane, and as all the structures of the plant arise in the first instance from a single bud, it is evident that a description of the latter will be of considerable interest. The first and most significant point in regard to the bud of the sugar-cane is its tendency to become a rhizome. It never develops aboveground to form a branch such as one sees in a dicotyledon, but remains latent until placed belowground, thus affording an additional proof that from its very beginning the sugar-cane is an underground plant, only sending up certain of its parts for necessary functions such as assimilation in the sunlight, and flowering. The base of every stem is a rhizome possessing its own root system and capable of independent growth, and so we must look on the eye of the sugar-cane as in no way parallel to the ordinary shoot of a dicotyledon, but rather akin to the process of budding-off of new plants which goes on in certain of the monocotyledons. Thus we find that a growing bud of the cane soon develops a root system, and it is a common sight to notice a shoot of about 6 inches long with two or three well-grown roots.

We may therefore look on the bud of the cane as practically a complete new plant budded off from the parent, requiring support from it for only a short period, and afterwards developing into a rhizome with numerous roots, and having the power of, producing new rhizomes as well as aerial culms.

As a fitting close to this paper, it might be well to make a few inquiries as to what bearing the facts disclosed may have on practical problems of planting. In a general way the acceptance of the view that the underground parts of the cane are really the chief structures of the plant, should tend to produce greater care in such operations as are likely to injure the stools. The loss of a rhizome means the loss of several of next year's stalks.

A second point on which the paper bears is in connexion with ratoon tillage. Among the numerous arguments which have been put forward against ratoon tillage is the comparatively unimportant one that cutting the roots of the plant cane may injure the ratoon growths, an idea arising from the mistaken notion that a ratoon is similar to a new

shoot of a pruned dicotyledon. The comparatively early age at which a ratoon can become independent of the plant, and also the fact that the plant cane is with certainty doomed to death after flowering, tend to establish the view that the only botanical question involved in ratoon tillage is to avoid cutting ratoon roots, in other words, to till as soon after reaping plant canes as it possible, if the state of the soil makes tillage a necessity.

OBSERVATIONS ON THE EFFECTS OF STORAGE ON COTTON SEED.

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Cotton seed at the present time is a product of considerable value in the West Indies, both from the point of view of growth of the cotton crops and also on account of its usefulness as a stock feed, and as an oil crop. On this account the changes which it is likely to undergo as a result of keeping are matters of importance.

It frequently happens that cotton seed may, for various reasons, be stored for considerable periods of time before it can be used, and observations are here brought forward which throw some light on a few of the effects likely to be induced by storing.

Such effects fall naturally under two heads: (*a*) Effects on the actual chemical composition of the seed: (*b*) Effects on the vitality or germinating power of the seed; and the results given below are grouped accordingly.

(a) *Effects of Storage on Chemical Composition of the Seed.*

When crushed cotton seed is mixed with water, the resulting mash is usually of a bright yellow colour. In February 1908 a sample of crushed cotton seed was received at the Government Laboratory for the Leeward Islands, which, when mixed with water in this way, was found to give a bright green colour, instead of the usual yellow tint.

At first sight it was thought that this peculiarity was due to the admixture with the sample of some inorganic mineral substance, such as Paris green, either by accident or intentionally; chemical examination, however, soon showed that this idea was erroneous, and that the green colouration was more

probably due to some organic substance derived from the seed itself. When the crushed seed was examined under the microscope, it was found that it contained numerous opaque masses, which broke down in glycerine and water to small round green bodies.

Enquiry elicited the fact that the seed in question was of considerable age, having been grown in 1906 and kept until 1908, before crushing. It therefore appeared likely that the development of the green colour might be due to changes which had taken place in the seed as a result of long keeping, and this supposition was subsequently verified, investigation making it clear that the observed appearances were due to changes in the resin masses.

If a cotton seed is cut across, the cotyledons are seen to be marked with a large number of dark dots; these are the resin masses mentioned above. According to Hanausek,' the secretion contained in them is 'olive-green, flowing out of the cavities in the form of a yellow-green emulsion, the particles of which are in lively motion. Strong sulphuric acid dissolved the secretion to a beautiful blood-red solution'.* A sample of freshly grown cotton seed was examined under the microscope in the laboratory in February 1908, when it was found that the secretion in the resin cavities appeared clear brown instead of olive-green, as stated above. Treatment with sulphuric acid gave a very beautiful crimson solution. On the other hand, when a sample seed which had been kept in the laboratory for some years was examined, it was found that the contents of the resin cavities were olive-green, as described above. Treatment with sulphuric acid resulted in the formation of a blood-red colouration as stated, but less intense in colour than with new seed.

From these observations, it appears that the contents of the resin cavities undergo change on keeping, either by oxidation or other means, whereby they are changed from a clear brown to a dark green.

This was subsequently verified by examining, after a lapse of fourteen months, seeds of the sample on which observations had been made when in fresh condition in 1908, when it was found that those seeds which had not undergone other changes now possessed resin cavities with dark-green contents. Hence it appears probable that Hanausek's observations were conducted on old seed.

Further, it was found that when seed of considerable age, of which the resin masses had become green, was crushed and mixed with water, the resulting mash was of a bright-green colour, exactly resembling the effect which originally called attention to the phenomenon in the case of the sample of crushed cotton seed first examined. (It is of interest in this connexion to note that the resin waste from refining cotton seed oil is used for the production of a green dye.)

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* *Winton's Microscopy of Vegetable Foods*, p. 209.

On cutting open and examining a number of fresh cotton seeds, it is generally found that a few of them are discoloured, being brown inside. This discoloration may vary considerably in extent, all stages being exhibited, from a slight to a complete change of colour. When thin sections of seeds affected in this way were examined under the microscope, it was found that the cell-walls were stained brown, and, in some instances, much disintegrated, and throughout the stained area numerous oil drops were distributed. It appeared that the brown staining was in all probability due to the bursting of the resin cavities already mentioned, whereby the contents became distributed throughout the body of the seed.

It was thought that possibly this might have been due to injury to the seed by the gins*, but the fact that the percentage of seed affected in this way tends to increase on keeping, would appear to negative this suggestion. Thus a sample of seed, which in February 1908 showed a percentage affected in this manner of 34, presented, eight months later, 66 per cent. of seed similarly affected. It is interesting to record that this increase corresponds approximately with the coincident decrease in the percentage of germination.

It is not clear whether the death of the seed was connected with this appearance, though it seems likely to have been. If it was, it yet remains to be decided whether it was the cause or the result of the phenomenon.

(b) *Effects of Storage on the Germinating Power of Cotton Seed.*

That cotton seed, on being kept, tends to lessen in its percentage of germination is a well-known fact. To investigate this, a quantity of fresh seed was taken in February 1908, stored in the Government Laboratory for the Leeward Islands, and periodical germination tests were conducted on it.

The results are given below :—

Date.		Germination, per cent.
February 24	1908	51
June 3	,,	49
September 14	,,	32
November 5	,,	36
April 24,	1909	8

The seed was stored in a covered wooden box lined with brown paper. The germination tests were performed on 100 seeds ; the germinator used was of the ordinary type, and was sterilized in every test by boiling before use. The seed used

*Injury by the gin may be sufficiently severe so that it is easily seen or that its effects are manifest in a short time. On the other hand, an injury from this cause, or from any other cause, such as the puncture produced by a cotton stainer or other insect, might be so slight that it could never be detected as an injury to the seed, and still be sufficient to liberate the enzymes which cause the changes in the substance of the seed. The action of enzymes being progressive and cumulative, the results in deterioration and in decreased germinating power would be similar to those obtained by Mr. Tempany.
[Ed. *W.I.B.*]

was from Centreville cotton grown at Skerrett's Experiment Station. It will be seen that the percentage germination of the seed was low, and decreased fairly steadily on storage. It was found that the decrease in the germinative power was of the same order of magnitude as in the increase of the seeds which showed the internal brown discoloration mentioned above. This is illustrated by the fact that in February 1908, the percentage of seeds thus affected was 34, while in November it was 66, as already stated.

To ascertain whether seed kept better if stored in an absolutely dry atmosphere, a portion of this same lot of seed was simultaneously preserved in a dessicator over strong sulphuric acid. In November 1908, this seed was examined at the same time as that stored under ordinary laboratory conditions. The percentage of germination was found to be 26. On cutting open and examining these seeds, it was observed that a large proportion showed the brown discoloration seen in seeds stored under normal conditions, the percentage of internally-brown seeds being 69. As one would expect, all the seeds examined were very hard and dry, doubtless on account of the exceedingly dry atmosphere in which they had been kept.

It appears, therefore, that storage under conditions of extreme dryness does not favourably affect the rate of deterioration.

SUMMARY OF CONCLUSIONS.

a. Cotton seed undergoes certain changes on being stored.

b. The contents of the resin cavities undergo a change the nature of which is not known, whereby the original brown colour is changed to green.

c. The resin masses tend to become ruptured, causing brown discoloration and disintegration of the internal tissues of the seed.

d. The germinating power tends to decrease on storage. This appears closely to follow the increase in the percentage of seeds showing brown discoloration, but whether this latter is a causative or consequent factor of the decrease of the percentage germination, is not clear.

e. The storage of cotton seed under very dry atmospheric conditions does not appear to affect favourably the decrease in germinating power, as compared with storage under normally dry conditions.

EUCALYPTUS IN THE WEST INDIES.

With a view to encouraging the planting of Eucalypts in the West Indies, to replace those trees that have been cut down for fuel, etc., there was reproduced in a previous volume of the *West Indian Bulletin* (Vol. IV, pp. 145-75) an account of the culture and uses of the Eucalypts by Mr. A. J. McClatchie, M.A., that appeared in Bulletin No. 35 of the Bureau of Forestry of the United States Department of Agriculture. That Bulletin gave, amongst other interesting data, a list of the species of Eucalyptus that are capable of withstanding the tropical conditions existing in the West Indian Archipelago. Since its publication considerable interest has been shown in the question of growing Eucalyptus trees in different parts of the West Indies, and it is desirable, with a view to showing what progress has been made, and the different species with regard to which the most success has been attained, to bring together and place on record such information as may be available at the present time.

Following is the information that has been obtained from officers of the Department and others in the different colonies:—

ST. LUCIA.

The Agricultural Superintendent of the Botanic Station, St. Lucia, writes:—

I have been through the trees in stock at the Botanic Station and find that there are two large Eucalyptus trees (unnamed), which are 60 feet high, with a girth of 6 feet. They are very vigorous and the seedlings thrive well.

The following seedlings are also in stock:—

10 *Eucalyptus leucoxylon*, 16 *E. robusta*, 48 *E. crebra*, and 10 *E. cornuta*.

These varieties all seem to do well here, and they rank in vigour and rapidity of growth in the order given.

DOMINICA.

The Curator of the Botanic Station at Dominica furnishes the following notes:—

I beg to forward a list of Eucalyptus trees growing at this Station. A list of seedlings in the nurseries raised from seed received from the Adelaide Botanic Gardens last year is also given. *Eucalyptus citriodora*, and *E. tereticornis* have given the best results in Dominica so far, both in the matter of general growth and as timber-producing kinds.

The following list includes the growing trees at the Botanic Station, with notes on their habits and growth: *Eucalyptus citriodora*, *E. tereticornis*, and *E. tesselaris* are rapid growers. These are the most useful Eucalypts in Dominica. *E. crebra* does not grow so rapidly as the above kinds; *E. corymbosa* grows quickly in height; lacks girth. *E. microcorys*, rapid

grower; good. *E. botryoides.* This species has not done very well. *E. rudis*, rapid grower; good. *E. punctata* has not done very well. *E. resinifera*, var. *grandiflora*, of fine growth. *E. obliqua*, rapid grower; good. *E. piperita*, of fair growth; *E. pilularis*, rapid grower; good.

The following is a list of the seedlings in the nurseries at the Botanic Station:—

Eucalyptus acmenioides	*Eucalyptus obliqua*
E. amygdalina	*E. odorata*
E. Baileyana	*E. occidentalis*
E. corynocalyx	*E. paniculata*
E. eximia	*E. punctata*
E. eugenioides,	*E. rostrata*
E. hemiphloia	*E. saligna*
E. leucoxylon	*E. sideroxylon*
E. macrorhyncha	*E. stuartiana*
E. Maideni	*E. tereticornis*
E. melliodora	*E. umbra*

MONTSERRAT.

The Curator of the Botanic Station at Montserrat writes:—

Eucalyptus citriodora, planted probably about 1902 at the Botanic Station. Height 50 feet; diameter at base 1 foot. No branches up to 20 feet, and above this, very few branches. Sparsely covered with foliage and not at all an attractive looking tree. Has not grown much this last three years.

E. cornuta.--Young plant in pot received from Antigua. Planted at the Botanic Station in March 1908. Present height 20 feet; diameter at base 4 inches. Very vigorous and ample foliage.

E. alba.—Seeds recently received from the Head Office. Six plants growing in the nursery, but not vigorously. They are about 2 inches high.

Seeds of seventeen species of Eucalyptus were recently received from Adelaide Botanic Gardens, Australia, but we have not succeeded in germinating one.

ANTIGUA.

The Curator of the Botanic Station at Antigua writes:—

There are but four species of Eucalyptus trees growing at the Antigua Botanic Station, namely:—

Eucalyptus rostrata.—Rate of growth rapid. Somewhat inclined to branch, but contains serviceable wood in the branches. Flowers and produces seeds freely, but, like many of the Eucalypti, a high percentage will not germinate. General development good.

E. cornuta.—Rate of growth fairly rapid. The main stem and branches have a tendency to twist and form elbows. General development fairly good.

E. citriodora.—Rate of growth fairly rapid. Straight-growing tree with but few branches. General development fairly good.

Eucalyptus sp.—An unnamed, rather slow-growing Eucalyptus tree exists at the Botanic Station, the development of which is good.

None of the seeds received from Australia germinated.

ST. KITTS.

The Agricultural Superintendent of the Botanic Station, St. Kitts-Nevis, writes:—

There are only seven large trees in the Station at present; many have died during the last few years. The outer bark peels off, then signs of decay set in, and in many instances the tree soon dies. This has also been the case with a long row of trees planted along the Mac Knight Road leading to the Station, which are gradually dying out from a similar cause. Also in the public Cemetery, where a large number of these trees were planted, they are getting fewer each year. These trees are from fifteen to eighteen years old.

The following is a list of the Eucalyptus trees planted out at the Botanic Station, St. Kitts: *Eucalyptus resinifera*, 3 large trees showing signs of decay. *E. tereticornis*, 2 trees, same as *E. resinifera*; *Eucalyptus* sp., 2 trees, not so large as the above, but in better condition.

The following list shows the species, with the numbers of each, of seedlings in the nursery:—

E. rudis (80)	*E. crebra* (40)	*E. Sieberiana* (30)
E. goniocalyx (30)	*E. Baileyana* (28)	*E. maculata* (28)
E. microcorya (24)	*E. melliodora* (20)	*E. citriodora* (15)
E. Maideni (12)	*E. odorata* (10)	*E. obliqua* (11)
E. pulverulenta (4)	*E. rostrata* (2)	*E. punctata* (2)

A total of 336 seedlings of fifteen species.

The young plants in pots listed herewith, have been grown from seed which was received from the Botanic Station, Adelaide, South Australia, in December 1908, and have made good progress. These seedlings are now ready for distribution.

GRENADA.

The Acting Agricultural Superintendent of the Botanic Station, Grenada, forwards the following description of labelled and unlabelled trees at that Station:—

LABELLED TREES.

Eucalyptus tesselaris.—This tree is straight, about 90 feet high, branches about 60 feet from the ground, and measures in circumference at base of trunk 5 feet 10 inches. Growth satisfactory; gum exuding freely.

E. alba.—Stem very smooth and white; branches low and spreads more than other varieties planted out; appears to be the fastest grower. Height about 70 feet, and measures at base of trunk 4 feet 10 inches. Growth satisfactory.

E. citriodora.—Tall and straight, branching about 70 feet to 80 feet from the ground. Trunk, at base of tree, 5 feet in circumference. Growth very satisfactory.

E. crebra.—Tree at this garden grows in a slanting position: height about 40 feet, circumference at base of tree 4 feet. Growth not so satisfactory as others already named.

UNLABELLED TREES.*

No. 1. Clear smooth bark; height about 60 to 80 feet: branching high, seeding freely; circumference at base of trunk 7 feet 8 inches.

No. 2. This tree is the finest of all the Eucalypti at the Station. The bark is cracked about 10 feet from the ground, where shaded, but is smooth from this to about 50 feet, where it branches and opens out into a pretty crown. The height is about 100 to 110 feet, and the trunk measures at the base 8 feet 9 inches in circumference. The growth is very satisfactory.

No. 3. Bark rough, and in appearance like *E. crebra.* The trunk is very straight and there are too few branches. Height about 100 to 110 feet; circumference at base 4 feet 2 inches.

No. 4. The bark of this tree is similar in appearance to *E. tesselaris*, but differs as regards the gum. The tree is about 90 feet high, very straight, branching about 60 feet from the ground and measuring 5 feet 10 inches in circumference at the base.

No. 5. Tree about 90 feet high and measures at base 6 feet 4 inches in circumference. Growth slanting like *E. crebra.* The bark is also rough, but the leaves differ both in smell and appearance.

No. 6. This tree is also a fine specimen with a pretty crown, and is straight in growth. The height is about 90 feet, and the circumference at base 7 feet 4 inches.

SEEDLINGS IN NURSERY.

Eucalyptus cornuta, E, affinis, E. pilularis, E. rudis, E. cosmophylla, E. robusta, E. hemiphloia, E. odorata, E. melliodora, E. Sieberiana, E. rostrata.

These were all that could be raised out of twenty-three different kinds of seed received at this Station.

ST. VINCENT.

The Agricultural Superintendent St. Vincent, writes:—

The following named species have grown successfully at the Botanic Station and Agricultural School, namely *Eucalyptus tereticornis*, and *E. crebra.*

*Leaves from these unlabelled trees were distributed to several of the Botanic Stations for identification. Mr. Jones, Dominica, identifies No. 6, as *Eucalyptus tereticornis*, and suggests that No. 5 is near *Eucalyptus crebra*,

Several other species have also done well, but the labels have been lost. They probably include *E. citriodora*, *E. saligna*, *E. capitellata*, and *E. paniculata*; plants of these having been raised and planted out.

Eucalypti such as above grow rapidly, and make strong healthy growth. They appear to do best here planted in groups or groves, and as wind-breaks. The planting of isolated trees is not to be recommended. Both on the poor soil at the Botanic Station, and the richer soil at the Agricultural School they have made satisfactory growth.

VIRGIN ISLANDS.

The Agricultural Instructor at the Experiment Station, Tortola, writes:—

There is only one species at present growing in this Station, and that is *Eucalyptus crebra*, seeds of which I obtained from Antigua. The largest tree is about 25 feet high and has a girth of about 19 inches at 1 foot from the ground. It is about four years old, and is growing in a fairly dry soil; but I think that at about 3 feet deep there is gravel, which is always moist. Probably the roots are now in this.

BARBADOS.

The Superintendent of Agriculture, Barbados, writes:—

At Dodds Botanic Station in the parish of St. Philip, there are two Eucalyptus trees growing, namely *Eucalyptus citriodora* and *E. crebra*. These trees are about sixteen years old and are at present some 60 feet high. In addition to these, I have in pots at Codrington, six plants of *E. odorata*, and eighteen of *E. robusta*.

I may add that some years ago I tried to grow *E. globulus* at Dodds, but after it reached a height of from 15 to 20 feet it stopped growing, gradually faded and eventually died. This, I understand, is the experience of growers of that species in the lowlands of the West Indies.

OBSERVATIONS ON MOLASSES.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S.,

Acting Government Chemist and Superintendent of Agriculture.

In view of the high prices at present prevailing for West Indian muscovado molasses, and for the exhausted vacuum-pan product, questions regarding the composition of the product, and the change which it is likely to undergo on storage, become of more than usual interest.

An account is given, herewith, of some observations carried out and results obtained in the Government Laboratory for the Leeward Islands, during the past twelve months on certain points connected with the behaviour of molasses.

The observations and results are grouped under two headings: The Froth Fermentation of Molasses, and the Souring of Molasses.

THE FROTH FERMENTATION OF MOLASSES.

It is well known that when molasses is kept it is liable to undergo changes, generally spoken of as fermentation changes. The two most common of these are frothing and souring, which are usually attributed to the action of organisms, and are supposed to be mutually interdependent.

Frothing is due to the evolution of gas, and is a well-known accompaniment of many different forms of fermentive activity. The manner of its occurrence in molasses varies according to the nature of the product.

In muscovado molasses, the most usual thing is for gas evolution suddenly to commence, the entire bulk becoming filled with small bubbles of gas, which, rising to the surface, cause much frothing, and may give rise to appreciable loss on account of overflow.

The duration of this gas evolution varies in different cases; it usually lasts two or three days in small samples, though in some instances it may suddenly commence, continue for a few hours, and then as suddenly cease. Its occurrence may or may not be accompanied by simultaneous souring and other relative changes.

In vacuum-pan molasses, the appearances are somewhat different. Once gas evolution has commenced, it usually continues for relatively long periods of time, often for several months. It is almost invariably accompanied by the rising to the surface of a thick, black scum, which increases in bulk as time goes on. It is also (as far as seen) always accompanied by true fermentive changes such as souring, disappearance of sugar, and the production of a vinous ethereal taste and smell.

It is usually thought that the occurrences described above are the result of fermentation by organisms, nevertheless it is

a matter of common experience that evolution of gas from massecuites will sometimes take place under conditions which would prohibit the existence of organisms in the active form, e.g. in the pan, or when still hot in the cooler. Phenomena such as these are usually ascribed to the breaking up of unstable, primary products formed by the action of lime and glucose, which are grouped for convenience under the general term of glucinates. These are salts of a hypothetical, glucinic acid formed by the decomposition of glucose.

This theory to account for the 'frothing fermentation' of massecuites was brought forward by Prinsen Geerligs as long ago as 1894, and suggestions were subsequently made by him, that the observed frothing in the case of molasses was in all probability due to similar causes.

Nevertheless, even at the present day, the subject is obscure, especially so in the case of muscovado molasses, which is a product relatively rich in sugar, and which has received but little attention at the hands of investigators.

It might be definitely settled whether this gas evolution is due, wholly or in part, to the activity of organisms, if suitable sterile culture solutions were inoculated with molasses exhibiting the phenomenon in question, to see whether the frothing is communicated in this way.

The following series of experiments was devised and carried out in order to try to solve the question on the above lines.

(1.) A solution was prepared, containing approximately, 60 per cent. sucrose and 6 per cent. invert sugar, and of a density of 1·32. Such a solution is very similar in saccharine richness and in density to a muscovado molasses.

Portions of this solution, sterilized by heating to 100°C., were inoculated (a) from a muscovado molasses which had previously frothed, and (b) from a second vacuum-pan molasses which was actively evolving gas. Both of these inoculated solutions were set up in flasks fitted with a gas delivery tube, and observed to see whether any gas was evolved. After an interval of three weeks (a) showed no sign of gas evolution; (b) also gave no sign of frothing or evolution of gas, though kept under observation for several months. In this solution, however, a flocculent white growth was developed.

(2) A sample of muscovado molasses which, after being kept for some months, was observed not to have frothed at all, was inoculated from a sample of second vacuum-pan molasses, which was then giving off gas vigorously. No perceptible frothing or evolution of gas took place during an interval of about six months, although a certain amount of growth, taking the form of a brown slime, which partly covered the surface of the molasses and sides of the containing flask, had taken place.

(3) A solution containing approximately 15 per cent. sucrose, a small amount of invert sugar, and traces of plant food constituents was prepared. This was divided into eight portions, which were sterilized in the steam oven at 100°C. Seven

of these were inoculated from various samples of molasses exhibiting the different stages of fermentation, and observed for a period of over a month. During that time all of the preparations showed marked signs of the growth of organisms, but in no case was any frothing or evolution of gas apparent.

These experiments show that the conditions giving rise to froth fermentation of molasses are not communicable by inoculation, and hence, that it is not due to the effects of organic activity. It would therefore appear to lend colour to the theory outlined above, that it is due to decomposition of products formed by the breaking down of glucose.

As already mentioned, the rate and manner in which gas is evolved, vary according to the nature of the molasses product, usually, with the muscovado, taking the form of a relatively sudden and brisk evolution followed by subsequent quiescence, while in the case of central factory molasses, gas evolution continues steadily over long periods of time.

The following data serve to illustrate the character of the occurrence in the second case. About 100 grammes of vacuum-pan molasses, found to be in process of giving off gas, were set up in a flask fitted with a gas delivery tube, and the volume of gas evolved was measured at stated intervals for fifty days. The results are shown below:—

Number of days.	Total volume. of gas evolved.	Rate per day.
3	29 c.c.	9·7 c.c.
7	50 ,,	7·1 ,,
11	74 ,,	6·7 ,,
13	90 ,,	6·9 ,,
18	108 ,,	6·0 ,,
35	160 ,,	4·6 ,,
50	175 ,,	3·5 ,,

It will be seen that the molasses continued steadily to evolve gas at a slowly decreasing rate during a period of fifty days.

When a sample of molasses evolving gas in this manner was sterilized by heating to 100°C. for half an hour, much frothing and evolution of gas took place. Subsequently the sterilized portion no longer continued to evolve gas, though an unsterilized portion still did so. It would appear that the heating sufficed to check all tendency towards further gas evolution.

It is not thought that this occurrence is due to the fact that sterilization killed the organisms which may have been responsible for the evolution of gas, but rather to the fact that the higher temperature caused the rapid decomposition of the gas-forming compound. At atmospheric temperatures, this decomposition proceeds much more slowly, and continues for a far longer time.

It is possible that the difference in behaviour observed in the case of the muscovado and of the vacuum-pan molasses, may be accounted for by the higher temperature at which the operations are carried out in the former process, causing the destruction of the greater part of the product responsible for the phenomenon, which does not occur to the same extent at the lower temperature of the vacuum-pan.

It has already been mentioned that in vacuum-pan products, evolution of gas is almost invariably accompanied by the rising to the surface of the molasses of a gummy substance. This substance is black and very sticky in appearance, and appears to consist largely of the bodies to which the gas evolution is due.

It was found possible, by carefully skimming the surface, to remove a quantity of this gummy product from a sample of second molasses found to be evolving gas freely.

A portion of this gum was found to froth violently, and to give off much gas when heated in the water-bath to 100°C.

A second portion was transferred to a pressure flask and the atmospheric pressure reduced by means of a filter pump to about 4 inches of mercury. As a result the gum immediately commenced to give off gas freely. When the vacuum was broken this gas evolution ceased, but on renewal it recommenced.

It appears, therefore, that lowering of pressure has a very similar effect to that of increase of temperature in hastening the rate of decomposition of the compound or compounds responsible.

It was further found, when determinations were made of the ash of this scum, and of the molasses underneath, that the ash of the scum was considerably in excess of the ash of the molasses, being as follows:—

Scum ash = 12·1 per cent.
Molasses ash = 7·1 ,, ,,

This is in accord with Geerligs' theory that these gas-producing products are compounds of bases with compounds formed by the breaking down of glucose.

It was thought that perhaps access of air to the molasses might have some influence on the breaking down of these substances, consequently a sample of vacuum-pan molasses which was evolving gas freely was placed in a glass cylinder and the surface covered with kerosene oil. It was found that the exclusion of air had no effect on the evolution of gas, which continued unchecked for upwards of a month; at the same time a considerable amount of gum rose to the surface. It was

further seen by this means that the probable reason for the rising of gums to the surface of the molasses is the formation of gummy envelopes with inclusions of gas contained in them, whereby the gum is brought to the surface of the molasses. In the foregoing experiment such envelopes were to be seen, during the later stages, suspended in the supernatant kerosene.

The effects observed appear to be due to the insolubility of these products, which exist in a state of suspension in the molasses. When these start to break down, they form aggregates which become distended with the evolved gas, and rise to the surface where the breaking-down process continues. The physical condition of this gum appears to resemble that of the mercury in the so-called ammonia amalgam. On prolonged keeping, the surface scum disappears, the contained gas in course of time becomes dissipated, and the scum sinks to the bottom of the molasses where it forms a slimy layer.

The fact that these products are insoluble is of practical importance in questions of manufacture.

At the present time the rôle played by gummy non-sugars in molasses formation is not clearly understood. The most widely accepted theory to account for the formation of molasses in cane-sugar manufacture is that of H. C. Prinsen Geerligs' whose summary of his theory is explained in his own words as follows: 'The entire action of molasses-forming is explained on the assumption that both sugar and glucose, and those products of decomposition of the latter which resemble caramel, have a tendency to combine with bases of the salts and hence to a certain extent act as acids.' (*Sugar and the Sugar-cane.* N. Deer, 1905. Edin., p. 281.)

On the other hand, Peck of the Hawaiian Sugar Planters' Experiment Station has shown that by removing gums from apparently exhausted molasses by precipitation with alcohol, it has been found possible to obtain a further crystallization of sugar, and in consequence, he shows a tendency to revert to the mechanical theory of molasses formation.*

From the large number of results on which Prinsen Geerligs bases his theory, as well as the theoretical soundness of his premises, his views would appear to be correct.

Local experience in Antigua, however, tends to bear out the view that gums exert some influence, since in recovery of second sugars at both factories in the island, lengthened experience shows that the best recovery of sugar in second massecuites is made when they are allowed to stand undisturbed in the coolers, after a preliminary stirring in the *malaxeurs*, when a copious layer of gum rises to the surface, leaving a massecuite comparatively easy to cure and one yielding a good recovery of sugar.

The suggestion has been made, that the explanation of the observations is, that in the case of gummy massecuites the gums may form a protective coating round the small crystals of sugar as they are formed, if the massecuite is kept in continued

*Hawaiian Sugar Planters' Association Bulletin.

motion, whereas if stirring is ceased after the first formation of crystals has taken place, the gums rise to the surface and cannot interfere with crystallization.

The essential feature of this theory lies in the insolubility of these products, since if they were soluble no such coating could occur. According to Prinsen Geerligs, the lime salts of glucinic acid are soluble, though the basic or so-called apoglucinates are not. It appears probable, therefore, that in the act of breaking down, these soluble lime compounds pass into insoluble compounds of a gummy nature, which, if continuously incorporated with the massecuite, may have the effect of coating the newly formed sugar crystal in the manner indicated above.

It may be that these insoluble compounds are capable of evolving more gas, or of combining with the glucinates in solution to form additional compounds capable of further activity in this direction.

Of these, those originally present consist largely of pectines and related bodies, while those subsequently formed are the result of the action of lime on glucose, and consist of the glucinates, etc., dealt with above.

The amount of pectinous matter occurring in an unclarified juice varies considerably, according as to whether the juice is a first, second, or third mill-juice, and also with the locality and weather conditions under which the cane has been grown; and this factor also influences the amount of gums removed by clarification. This, according to analyses by Geerligs, varies from 0·4 to 0·8 of the quantity originally present.

It is well known that juices from canes grown in certain fields and on certain estates are more likely to give rise to gummy and frothing massecuites and molasses than those from others grown in more favourable localities. This is noticeably the case on some of the extremely calcareous soils of the windward district of Antigua, and the suggestion is made that, possibly, part of the effect observed may be due to the fact that the extreme alkalinity of the soils lead to the absorption of a relatively large amount of lime salts through the roots, which may tend to induce the formation of a larger proportion of the gummy products of glucose decomposition than is normally the case.

This view is supported by the fact, that analyses of clarified juices from estates in the limestone districts, noted for the production of gummy massecuites and frothy molasses, showed that they contained but little pectine. It should be added that these juices were all obtained from single mills.

As a result of the observations recorded, herewith, the suggestion is made that the gums responsible for the effects quoted above, in preventing crystallization, are more particularly those formed, by the action of mineral salts on the glucose during the process of manufacture, and possibly also on the residue of soluble gums remaining in the juice after clarification. These latter gums, in an unchanged condition, have probably considerably less effect.

The following results, which show in pounds per gallon, illustrate this point :—

	ESTATE A.			ESTATE B.		
	I. lb. per gallon.	II. lb. per gallon.	III. lb. per gallon.	IV. lb. per gallon.	V. lb. per gallon.	VI. lb. per gallon.
Sucrose	1·88	1·96	1·92	2·03	1·90	2·00
Glucose	·08	·05	·05	·05	·06	·06
Non-sugars	...	·03	·02	...	·02	·01
Ash	·05	·05	·06	·05	·05	·05

Each of these analyses represents an average of samples taken at regular intervals throughout the work of an entire week.

Before closing this portion of the paper, reference may be made to some observations by Dr. Watts and the present writer on 'Fermentation Changes Occurring in Muscovado Sugar' (see *West Indian Bulletin*, Vol. VII, p. 226), in which attention is directed to the evolution of gas by samples of muscovado sugar in a state of fermentation.

When this paper was begun, it was thought that this gas evolution was one of the manifestations of the action of the organisms responsible for the other changes, but the view is now put forward that, in all probability, it was a separate and distinct phenomenon attributable to the decomposition of glucinates in the sugar. In this connexion attention may be drawn to the statement contained in the paper, that this fermentation tends to occur concurrently with the appearance of gum in the juices and massecuites.

SUMMARY OF CONCLUSIONS.

1. The 'froth fermentation' of molasses is due not to the action of organisms, but to the decomposition of gummy substances (glucinates) formed by the action of lime on glucose, which break down with evolution of gas.

2. In vacuum-pan molasses these gums, in course of time, generally rise to the surface in an impure state. The gum thus separated is insoluble in the molasses ; it possesses a higher ash content than the molasses from which it is separated.

3. The suggestion is made, that these products, on account of their insolubility, may influence the recovery of sugar from second massecuites, the small crystals as they are formed

being surrounded by a protective covering of this gum. This can be avoided to an extent by allowing the massecuite to stand undisturbed, when these gums rise to the surface.

4. The suggestion is also made that the reason, why juices from canes grown on certain highly calcareous soils are very liable to give extremely gummy products, is that the excess of lime in the soil increases the amount contained in the juice, and gives rise to additional formation of glucinates.

THE SOURING OF MOLASSES.

While it appears that the 'froth fermentation' of molasses is not a process attributable to the activity of organisms, there are other changes likely to take place in molasses which undoubtedly originate from such activity. These are generally known, collectively, as souring, and under this name must be grouped such changes as the development of an acid taste and smell, the loss of sweetness and palatability, etc. Sometimes a vinous odour may result, and sometimes a mouldy taste and smell. All these and other changes are likely to take place, their exact nature being dependent on the organism by means of which they are brought about.

Such changes are very liable to occur, and this renders them worthy of investigation at the present time, when the price of the muscovado product is comparatively high, and especially since changes of this description are likely to result in considerable damage to the article in question.

With these facts in mind, a series of experiments was carried out to throw light on this matter of souring. The experiments consisted of (1) a series of inoculations of sterile culture solutions of sugar with material from a number of samples of molasses which had been found to be in a fermenting condition: (2) a series of analyses of molasses which have been in a state of fermentation for some time, in order to investigate the nature of the changes taking place.

(1) A solution was prepared containing, approximately, 15 per cent. sucrose, a small quantity of invert sugar, and traces of plant food constituents. This was divided into eight equal parts of 100 c. c. each, transferred to eight flasks which were plugged with cotton wool, and sterilized by heating to 100°C. in a steam oven for one hour. Seven of these were inoculated from samples of molasses which had shown signs of fermentation, and the eighth was left blank. These flasks were lettered A to H, and the origin of the samples from which each was inoculated is stated below.

A and B were inoculated from samples of fermenting second vacuum-pan molasses; C, D, E, and F from fermenting Antigua muscovado molasses; G from a St. Kitts muscovado molasses, while H was not inoculated, but kept blank as a control.

These were left for a period of five weeks. At the end of that time they were opened, the microscopic and macroscopic appearances of the contents of the flasks were described, and the various liquids analysed.

The results are given in the subjoined table.

A.

Appearance in flask.—Liquid turbid and thick. Surface covered with top growth, with black and velvety surface appearance. Some bottom growth. Mouldy smell.

Appearance under the microscope.—Top growth consists of aspergillus-like conidiophores together with a branching mycelium, and an organism which appears to be *Bacillus pasteurianus.*

Analysis.—Polariscope - 14·3. Glucose 12·4 grammes per 100 c c. Acidity per 100 c.c. = 18 c.c. $\frac{N}{10}$ acid.

B.

Appearance in flask.—Top growth resembling A. Liquid clear. Some bottom growth. Mouldy smell.

Appearance under the microscope.—Resembling A.

Analysis.—Polariscope - 16·9. Glucose 12·4 grammes per 100 c.c. Acidity per 100 c.c. = 58 c.c. $\frac{N}{10}$ acid.

C.

Appearance in flask.—Brownish-yellow top growth. Solution turbid and brownish-yellow in colour. Small amount of bottom growth. Faint sour smell.

Appearance under the microscope.—Top growth consists of aseptate hyphae with some brownish threads (crenothrix ?). Round, yellow conidia.

Analysis.—Polariscope + 1·1. Glucose 11·12 grammes per 100 c.c. Acidity per 100 c.c. = 10 c.c. $\frac{N}{10}$ acid.

D.

Appearance in flask.—Very small amount of dark, leathery top growth. Faint amount of ropy bottom growth. Faint sour smell.

Appearance under the microscope.—Bottom growth appeared to consist of small, oval bacteria.

Analysis.—Polariscope - 6·3. Glucose 12·75 grammes per 100 c.c. Acidity per 100 c.c. = 5 c.c. $\frac{N}{10}$ acid.

E.

Appearance in flask.—Yellowish-grey top growth resembling C. Small amount of brownish bottom growth. Solution turbid and yellow-tinged.

Appearance under the microscope.—Top growth closely resembled C. Bottom growth apparently consists of settled top growth.

Analysis.—Polariscope - 4·7. Glucose 12·4 grammes per 100 c.c. Acidity per 100 c.c. = 5 c.c. $\frac{N}{10}$ acid.

F.

Appearance in flask.—Little or no top growth. Small amount of ropy bottom growth. Liquid clear and colourless. Faint sour smell.

Appearance under the microscope.—Contains a number of bacteria, notably a small coccus slightly stained by fuchsin. A few yeasts.

Analysis.—Polariscope + 15·8. Glucose 8·5 grammes per 100 c.c. Acidity per 100 c.c. = 5·5 $\frac{N}{10}$ acid.

G.

Appearance in flask.—No top growth. Small amount of powdery bottom growth. Liquid clear and colourless. Faint sour smell.

Appearance under the microscope.—Bottom growth resembled F, and contained also a crenothrix-like form.

Analysis.—Polariscope + 3·6. Glucose 10·9 grammes per 100 c.c. Acidity per 100 c.c. = 6 c.c. $\frac{N}{10}$ acid.

H.

Appearance in flask.—Clear and colourless.

Appearance under the microscope.—No growth.

Analysis.—Polariscope 57·3. Glucose 0·7 grammes per 100 c.c. Acidity nil.

The foregoing shows the number and variety of bacteria and fungoid forms likely to occur in West Indian molasses under ordinary conditions.

The following analyses illustrate the changes likely to take place in molasses as a result of organic activity.

A sample of 2nd vaccum-pan molasses, which was in a state of active fermentation in August 1908, had the following composition at that time :—

Sucrose	41·3	per cent.
Glucose	10·8	„ „
Ash	6·2	„ „
Water	38·8	„ „

Specific gravity 10 per cent. solution 1·0230 @ $\frac{30^\circ}{16\cdot6^\circ}$

In March 1909, another analysis was made of this molasses, and the changes which had taken place as a result of the fermentation may be seen by comparing the following analysis with that of August 1908 :—

Sucrose	9·7	per cent.
Glucose	33·8	„ „
Ash	5·5	„ „
Water	38·0	„ „

Specific gravity 10 per cent. solution = 1·0228 @ $\frac{30^\circ}{16\cdot6^\circ}$

This sample had a strong vinous odour.

The fermentation, as will be seen, has resulted in the conversion of a very large proportion of the sucrose into

reducing sugars, while approximately 10 per cent. of sugars has been destroyed.

Another sample of 2nd vacuum-pan molasses which had been kept during the same period of time showed at the end of that time the following composition :—

Sucrose	5·6	per cent.
Glucose	33·8	„ „
Ash	5·9	„ „
Water	37·6	„ „

The sample polarized 27·7 and had an ash content of 7·5 per cent. when first received. It also had a strong vinous odour at the time of the second analysis. The changes which took place are seen to be similar in character to those taking place in the first case.

It will be seen that a reduction of the ash content has taken place in both cases. This is probably attributable to the glucinates being thrown out of solution as described in the first part of this paper, and since these possess a relatively large amount of mineral matter in combination with organic matter, their removal tends to reduce the ash content of the molasses by an appreciable amount.

From the foregoing, the liability of molasses to undergo fundamental changes in composition through the activity of organisms is well shown, as is also the wide-spread occurrence of various organisms in different samples.

Further, these changes in composition are almost invariably accompanied by alterations in flavour, which tend to make the molasses unpalatable.

Observation inclines one to the belief that these changes are more liable to take place in exhausted vacuum-pan molasses than in the muscovado product.

In this connexion, attention may be directed to the report of the General Committee of the Barbados Agricultural Society on the causes of the souring of molasses (see *Agricultural News*, Vol. VII, p. 67), where the statement is made that souring 'may be prevented or delayed by the presence of certain substances in molasses whose nature is not understood'.

The further statement is made in this report that the souring is due to the production of acetic acid from alcohol formed by the action of yeasts on sugar which, reacting upon salts of other organic acids, liberates them, thereby imparting the disagreeable flavour to the product.

That this view is probably correct is borne out by the presence in two of the inoculated solutions described above of *Bacillus pasteurianus*, which causes the production of acetic acid in the manner described.

If the view indicated above is correct, that muscovado molasses owes its relative immunity from the action of ferments to the presence of obscure bodies exercising an inhibitive influence, it is difficult to see why exhausted vaccum-pan molasses which is manufactured under conditions far better controlled, should have a greater tendency to ferment.

It may be that spontaneous separation of a considerable amount of non-sugar as insoluble gum, leaves a medium better suited for the growth of organisms than in the case of muscovado molasses where, for a reason not entirely obvious, a similar separation does not take place. This may possibly be on account of the higher temperature to which the liquor is heated in the course of manufacture.

On the other hand, it may be that the ratios of sucrose and glucose to water in the muscovado product unfavourably affect the growth of organisms.

Be this as it may, the fact remains that on certain occasions muscovado molasses is liable to undergo changes due to fermentation, and that the value of the product is liable to be unfavourably affected thereby.

At the present time, muscovado molasses stands at a price which renders it the most valuable product of the sugar industry. It is therefore obvious that every care should be taken to avoid all risk of the changes indicated above taking place. This is secured by the observance of the utmost care and cleanliness in the process of manufactuie and storage.

Nevertheless it cannot be denied that, in many instances the conditions under which molasses is manufactured, and stored in the Leeward Islands are such as to provide surroundings admirably suited for the development of deleterious organisms. It is urged that more care and attention in this direction is, in the interest of the industry, urgently called for.

In this connexion the writer would most heartily endorse the recommendations of the Barbados Committee and urge their wholesale adoption as far as possible in the Leeward Islands.

For convenience of refeience they are reproduced below.

(1) Temper and boil the juice in the ordinary way and do not boil too low.

(2) Do not mix syrup with molasses.

(3) Be careful of the cleanliness of the gutters or pipes leading to the oscillators or coolers, and from them to the centrifugals, and from the centrifugals to the molasses cistern. Avoid closed pipes as far as possible, as one cannot see inside them.

(4) Be careful of the cleanliness of the curing boxes when such are used. They ought periodically to be thoroughly cleaned and finally sterilized with a steam jet if possible, or rinsed with bisulphite of soda solution; or failing that, with weak milk of lime, and then dried with dry bags that have been washed.

(5) Be scrupulously careful about the condition of the molasses cistern and as far as possible of the stancheon. Avoid water leaks of all descriptions. If a cement cistern cracks, peck up the bottom all round the crack and replace with fresh, sound cement, etc. Clean out the molasses cistern as often as possible. Finish off with bisulphite of soda or milk of lime, and dry afterwards.

(6) Avoid second-hand puncheons or shooks, as they will probably be impregnated with the germs of fermentation.

(7) Pay great attention to the rinsing out of the puncheon before it is filled. It should be first drained, then rinsed out thoroughly with ordinary, clean water. The best way of finishing the cleansing is to play on the interior with a steam jet, and then drain, or rinse out with boiling water and drain. Failing these, rinse out finally with bisulphite of soda or thin milk of lime, and drain.

(8) If possible, it is desirable that out rods and sampling instruments should always be washed between one puncheon and the next. It is suggested that the ordinary out rods might be copied locally in pine so that each gauger has 50 or 100 to work with, enabling them to be washed in batches.

(9) Filling up one puncheon from another and 'running' are undesirable wherever they can be avoided; chiefly because of the risk of infecting a good molasses with a bad one.

THE PACKING FOR TRANSPORTATION OF SUGAR-CANES FOR PLANTING.

BY J. R. BOVELL, I.S.O., F.L.S., F.C.S.,

Superintendent of Agriculture, Barbados.

Soon after seedling sugar-canes were first grown in Barbados applications were received from all parts of the world for the best of those under cultivation. It therefore became necessary to devise some method of packing canes to be sent to distant countries so as to ensure their arrival in good condition. After various methods had been tried with more or less ill success, even including sending them in Wardian cases, the following method, which has proved very successful, has been adopted.

The sugar-canes for transportation are cut at the station at which they are grown, in lengths of about 4 feet 6 inches, wrapped in sacking to avoid injury to the buds, and taken to the central station where they are to be packed. On their arrival, or, if they reach the station too late, on the following morning, about 3 inches are removed with a sharp knife from the ends of each stalk, and the sugar-canes immediately immersed in Bordeaux mixture and allowed to remain for half an hour. The object in cutting off the ends of each stalk is to ensure that any fungus spores which may have germinated on the cut ends are removed. As soon as the stalks are removed from the Bordeaux mixture and have dried sufficiently, the ends are sealed with resin to which sufficient tallow or other grease has been added to prevent the resin from being too brittle.

The canes are then labelled either with pieces of tin on which the numbers of the canes are recorded by punching with a sharp instrument, or with pieces of zinc on which the numbers are stamped with a steel die. The canes are now packed in cases 4 feet long by 1 foot wide by 1 foot deep, in damp, powdered charcoal which has first been passed through a sieve having 144 meshes to the square inch. From a number of experiments it has been found that in damping the charcoal $\frac{3}{4}$ pint of water to 1 lb. of charocal gives the best results. Each case should contain about 60 lb. of canes packed in about 60 lb. of charcoal (weight before damping).

Sugar-canes packed in the manner described above have at various times been kept for three months and over. A case

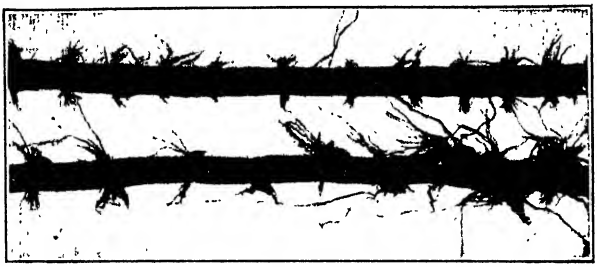

FIG. 11. Sugar canes photographed after having been packed in damp charcoal for three months and twenty days.

of canes was recently kept for three months and twenty days, and at the end of that time they were in excellent condition.

Two of these canes were photographed (see Fig. 11), and were then planted, and the growth of young sprouts was photographed (see Fig. 12).

FIG. 12.—Sprouts from the canes shown in previous figure.

That sugar-canes packed by this method have reached their destination in good condition may be gathered from the following extracts from letters from persons to whom they have been sent:—

On March 19, 1907, a box of cuttings was forwarded to the Royal Botanic Gardens, Sibpur, Calcutta, India, and the Superintendent wrote on June 14, 1907: 'The cuttings of sugar-cane referred to therein have reached here in good condition'.

On May 22, 1907, two boxes of cane plants were shipped, via New York, to Mr. E. J. F. Campbell, Superintendent of the Botanic Station, British Honduras, who wrote on June 27, 1907: 'I am pleased to state that these have arrived safely, and in good condition'.

At the beginning of December 1907, there were packed for Mr. James Clarke of the Colonial Refining Company of Queensland, who had been sent to Barbados and British Guiana to obtain seedling canes of the best varieties, two cases of sugar-canes in the manner described above. Mr. Clarke reached Fiji where the canes were to be planted, on February 28, 1908, nearly three months after they were packed. Shortly after their arrival in Fiji he wrote to say: 'All of these plants (those packed in damp, powdered charcoal) I am pleased to say have made excellent growth. They have come up as quickly and look as well at the present time as fresh cuttings raised locally and planted fresh from the cane knife would do. ...... The damp powdered charcoal packing has really solved the problem of being able to transport cane cuttings to any part of the world, and I congratulate you on the discovery. ...... Not more than a dozen cuttings failed to grow out of 270 planted (i. e., less than 5 per cent.)'.

In December 1907, one case of canes was forwarded to Dr. C. J. van Hall, Director of the Experiment Station, Paramaribo, who wrote: 'I have now the pleasure to inform you that the samples of sugar-cane arrived in very good condition'.

On February 22, 1908, three cases of cuttings were forwarded, via New York, to Dr. J. T. Crawley, Director of the Estacion Agronomica, Santiago de las Vegas, Cuba, who wrote: 'I take pleasure in informing you that the canes have been received in splendid condition. The eyes had sprouted in many cases and the stalks were surrounded by the young rootlets'.

In March 1908, a box of cane plants was shipped to Messrs. Felix et Gustave Vandesmet, Usina Brazileiro, Atalaia, Maceio, Brazil, and in reply these gentlemen wrote as follows: 'We have to acknowledge the receipt of your letter of March 25, together with the case of cane plants, which arrived in perfect condition. We planted them out on April 27; all the cuttings had already a fairly developed root, and the eyes swollen. Some of these had even opened and the first leaf come out. After being planted fifteen days the canes sprang, and are, on the whole, vigorous; it is now thirty-five days and all the cuttings are in fine growth, the majority giving five or six plants'.

On February 10, 1909, seven cases of canes were sent to the same gentlemen, who in acknowledging their receipt said: 'All the cuttings have arrived in perfect condition, the charcoal being still damp, the canes having commenced to grow, and we do not think we will lose one of them. The first lot arrived in the same condition and have given satisfactory results'.

On February 23, 1909, two cases of sugar-canes were forwarded to Mr. Alfredo de Fraga Gomes, Rua da Rochinha, 49, Funchal, Madeira, who wrote: 'I have received your esteemed favour of February 23, also two cases containing sugar-canes in very good condition'.

On March 22, 1909, two cases were also forwarded to Mr. P. E. Boname, Director of the Station Agronomique, Reduit, Mauritius, who wrote: 'The cuttings arrived in good condition in spite of the length of the voyage (I was only able to open the boxes on May 27), with the exception of the No. 6,204, but I hope nevertheless to save at least one plant of this variety which will be sufficient to propagate it.

On March 30, 1909, two cases were sent to Dr. D. M. May, Special Agent-in-Charge, Experiment Station, Mayaguez, Porto Rico, who wrote: 'The canes arrived in good condition and I believe will grow. Some fine roots had put out from the joints and the buds had swollen, some making a growth of one or two inches'.

On the same date a case of cuttings was forwarded to Mr. John Belling, B. Sc., Agricultural Experiment Station, University of the State of Florida, Gainesville, Florida, U.S.A., who wrote as follows: 'The sugar-canes you kindly sent us came to hand in excellent condition on April 17. Most of the nodes had emitted roots, and some of the buds had grown out. There was no decay whatever at the ends or elsewhere. . . . . . We are much obliged to you for selecting the canes, and for the excellent packing, which enabled them to reach us in such good condition'.

From the above it will be seen that sugar-cane cuttings can now, by being packed in damp, powdered charcoal, be sent to any part of the world with the likelihood of their reaching their destination in good condition.

There is one other matter in connexion with the transportation of canes I would mention, and that is, the cases should not be opened until they are to be planted, as if this is done and the rootlets are exposed to the air for any time before they are planted, they become dry and consequently die.

The photographs, from which Figs. 11 and 12 have been prepared, were made by Mr. H. A. Ballou, M.Sc., Entomologist on the staff of the Imperial Department of Agriculture.

DISTRIBUTION OF ECONOMIC PLANTS FROM WEST INDIAN BOTANIC STATIONS.

In 1906, the late Mr. W. R. Buttenshaw, M.A., B.Sc., prepared an account of the work of the West Indian Botanic Stations in raising and distributing seeds and plants useful in the development of the agriculture of the islands. This paper appeared in the *West Indian Bulletin*, Vol. VII, p. 374.

In addition to the raising of plants and seeds, the Botanic Stations are extremely useful in the matter of purchasing seed for sale at cost price to planters and peasants, and in exchanging desirable varieties of plants from one island to another. The local agricultural officers are able to keep informed of the agricultural wants of the colony, and to anticipate to a certain extent the demand for special plants, and thus be able to supply them at the shortest possible notice.

The information contained in this account has been largely supplied by the officers of the local Departments of Agriculture in each island, and reference has also been made to the Reports of the Botanic Stations.

At the end of the paper already mentioned, the following table was published :-

TABLE I.

TOTAL NUMBER OF ECONOMIC PLANTS DISTRIBUTED FROM THE WEST INDIAN BOTANIC STATIONS, 1901-2—1905-6.

Station.	1901-2.	1902-3.	1903-4.	1904-5.	1905-6.	Total.
Tobago ...	4,550	7,605	7,445	9.535	9,538	38,673
Grenada ...	8,794	7,584	5.657	3,534	4,532	30,101
St. Vincent ...	24,033	7,670	13,536	26.256	17.543	89,038
Barbados* ..	...	...	..	...	..	...
St. Lucia ..	15.461	26,637	10,216	13,103	25.675	91.092
Dominica ...	60,533	57,131	53.500	46,736	65.731	283,631
Montserrat ...	11.817	19.737	19.690	11,887	6,771	72,905
Antigua ..	6,465	2,961	1.928	1.415	2,561	15,330
St. Kitts ..	..	...	...	1,377	860	2,237
Virgin Islands*	...	...	...	...	...	...

* The economic plants distributed from the Botanic Stations at Barbados and Tortola during the period 1901-6, consisted largely of cuttings such as canes, cassava, etc., and there were also considerable quantities of seed distributed.

The total number of economic plants as shown, amounts to 621,007 for the five years under review. Since the time covered by the figures given in the preceding table, the Botanic Stations have gone on with the work of raising and distributing economic plants. The extent of this work during the past three years is shown in Table II.

TABLE II.

NUMBER OF ECONOMIC PLANTS DISTRIBUTED FROM THE WEST INDIAN BOTANIC STATIONS, 1906-7 TO 1908-9.

	1906-7.	1907-8.	1908-9.	Total.
Grenada ..	1,164	1,154	5,653	7,971
St. Vincent ...	10,143	5,148	5,489	20,780
St. Lucia ...	64,240	73,538	32,975	182,376
Barbados* ..	...	...	...	.
Dominica ..	83,505	53,855	67,498	204,958
Montserrat ...	11,975	3,296	182,963	198,234
Antigua ..	2,880	14,522	7,256	24,658
St. Kitts ...	711	564	6,476	14,117
Nevis	...	3,600	2,766	
Virgin Islands	300	200	550	1,050

In Table III, the totals are given of the economic plants distributed from each Botanic Station, with a partial analysis in each case of the figures. It will be seen by comparison with the amounts given in succeeding paragraphs, that such items as sweet potato, cane, and cassava cuttings, and plants of pine-apples, bananas and plantains are not included in the tables. The numbers of these would increase the figures given in the tables very greatly. In the Virgin Islands, for instance, the Tortola Experiment Station distributed some 8,000 onion plants; at Montserrat the distribution of cuttings would bring the figures for 1908-9 up to over 180,000.

Considerable quantities of seed and large numbers of cacao pods are also distributed.

The figures showing the number of cacao plants distributed at Dominica include grafted cacao as follows: 1906-7, 200 plants; 1907-8, 146 plants; 1908-9, 235 plants; and at the same Station the figures for budded citrus plants include over 1,000 budded Navel oranges in 1908-9.

In St. Lucia, the rubber distributed in greatest numbers is *Castilloa elastica*, of which species some 7,000 plants were distributed in 1907-8.

In St. Kitts-Nevis and Antigua also, large numbers of cuttings of canes, cassava and potato have been distributed.

* See page 149.

TABLE III.

	1906-7.	1907-8.	1908-9.
Grenada ...	1,164 Cacao 388	1,154 Cacao 500 Rubber 500	5,652 Agave 2,000 Castilloa 1,250 Cacao 715
St. Vincent ...	10,143 Cacao 6,465 Rubber 2,040 Nutmeg 947 Madura 1,692	5,148 Cacao 4,520 Nutmeg 468 Rubber 53	5,489
St. Lucia ..	64,240 Limes 37,116 Rubber 18,167 Cacao 5,864 Nutmeg 795	73,538 Limes 56,425 Cacao 7,017 Rubber 7,438 Coffee 1,165	32,975 Limes 23,610 Cacao 6,090 Coffee 1,094 Rubber 805
Dominica ...	83,505 Limes 69,312 Cacao 9,205 Rubber 1,557 Nutmeg 980	53,855 Limes 47,140 Cacao 4,399 Rubber 550 Budded citrus 503	67,598 Limes 55,648 Cacao 5,848 Rubber 1,889 Budded citrus 1,247
Montserrat ...	11,975 Limes 5,562 Cacao 1,043 Rubber 913 Bay 900	2,992 Limes 1,340 Ramie 1,000 Cacao 60	5,307 Cacao 1,502 Limes 1,900 Bay 1,435
Antigua ..	1,876 Citrus 800 Mahogany 554 Rubber 250	13,606 Limes 8,800 Lemon grass 3,880 Cocoanuts 217	7,256 Citrus 3,650
St. Kitts ...	711 (Rubber)	564 Rubber 310	6,476 Limes 5,600
Nevis ..		3,600 (Limes)	2,766 Limes 2,000
Virgin Islands	192 (Cacao)	345 Cacao 175 Limes 170	552 Limes 540 Cacao 12

BARBADOS.

Mr. J. R. Bovell, I.S.O., F.L.S., has furnished the following information:—

Of a total of 23,166 economic plants distributed from the Botanic Station in 1907-8, 27 were grafted mangos, 7 were spineless limes, while the remainder were cuttings.

Of the cuttings, 16,724 were cane plants, 4,000 sweet potatos, 2,240 yams, 56 eddos and tannias, and 53 cassava.

In 1908-9, the total was 8,504, of which 6,685 were cane plants, 1,407 cassava, 300 yams, and 110 eddoes anb tannias, while there were only 6 grafted mangos.

In addition to the plants, seeds have been distributed from the Barbados Botanic Station as follows:—

In 1907-8, 3 barrels of mahogany seeds, 25 gallons of leguminous seeds, 223 lb. of ground nuts.

In 1908-9, 2 barrels of mahogany seeds, 48 gallons of leguminous seeds, 7 barrels of guinea corn in the ear, and 2,806 lb. of cotton seed.

ST. LUCIA.

In the years 1907-8 and 1908-9, the number of economic plants distributed from the St. Lucia Botanic Station was 118,136. Of these, 83,035 were limes, 13,108 cacao, and 8,243 rubber. There was also an increasing demand for coffee, 2,482 plants of the Liberian, Arabian, *Stenophylla*, and Mocha varieties having been sent out from the Station during the period.

ST. KITTS-NEVIS.

The number of economic plants sent from the Botanic and Experiment Stations of this Presidency aggregated 74,666 during 1907-8 and 1908-9. No fewer than 11,200 lime plants were distributed, whilst the demand for cane cuttings and cassava exceeded that of recent years, 37,000 of the former and 22,600 of the latter having been distributed.

MONTSERRAT.

The total number of economic plants distributed from the Montserrat Botanic Station for the last three years 1906-7 to 1908-9 has been 198,234, as compared with 72,905 for the five years immediately preceding. Of these, limes and cacao were in greater demand, no fewer than 8,082 plants of the former and 2,905 of the latter being sent out. Bay trees also showed an increase over the distribution for the previous period, 2,335 plants having left the Station.

TORTOLA.

The total number of economic plants distributed from the Experiment Station, Tortola, during the three years 1906-7 to 1908-9 was 10,676. Of these, onions were in greatest demand, no fewer than 8,000 seedlings having been sent out during 1907-8 and 1908-9. There was a much greater demand for lime plants than in previous years, 710 plants having been sold.

Antigua.

During the past three years the number of economic plants distributed from the Antigua Botanic Station has largely increased. This is attributable to (a) the increasing interest now being shown in the planting of permanent crops, notably limes and cocoa-nuts, and (b) to the increasing demand for forest trees for planting in open spaces which has arisen of late years.

The total number of plants distributed in each year is as follows:—

1906-7	2,880
1907-8	14,522
1908-9	7,256

As instancing the great increase in the distribution which has taken place, it may be pointed out that the number of plants distributed in 1907-8 fell very little short of the total number of plants distributed during the period 1901-6.

The demand for citrus plants is now considerable, some 8,800 being distributed in 1907-8 and 3,650 in 1908-9.

The Station has continued also to distribute a large number of cuttings, most of which are of sweet potato varieties, the distribution ranging from 3,270 in 1907-8, to 15,239 in 1908-9. There has also arisen considerable distribution of seeds of various beans and peas for green dressing purposes. With the centralization of the work of supervision of sugar-cane experiments under the Curator, the distribution of cuttings of different varieties of sugar-cane has become a part of the routine work of the Station. As stated in the *West Indian Bulletin* (Vol. VII, p. 384), it was until 1904 the custom to sell the surplus cane plants in the variety nurseries by auction. Owing to circumstances this practice fell into abeyance during 1905 and 1906, but was revived in the subsequent year, and has been continued annually since. In this way 71,000 cane plants, comprising some forty different varieties, were sold by public auction and distributed to the purchasers from the Botanic Station.

Dominica.

The average number of plants distributed from the Dominica Botanic Station during the last three years, 1906-7 to 1908-9, is 68,319, with a total for that period of 204,958. Of this number no less than 172,100 were lime plants, 148,839 being of the common kind, and 23,261 of the spineless variety.

To the end of the official year 1906-7, lime plants were sold at the rate of 1*s*. per 100 plants. Two years ago the price was raised to 2*s*. 6*d*. per 100, in order to make it profitable for private enterprise to share in the work of raising these plants, the demand for which threatened to become too great for the Botanic Station nurseries to meet. Several private nurseries are now supplying plants, and some estates raise their own. The rate of planting is greater than is shown by the distributions from the Government nurseries.

That there is a considerable demand for spineless limes is shown by the distribution during the past three years. Interesting information on this variety is given in the Annual Report on the Botanic Station for 1906-7.

Cacao occupies the second position, with a total for the three years of 19,059 plants and 2,633 pods. The plants are raised in bamboo pots, and owing to difficulties of transport are available only for coast estates on the leeward side of the island. The pods are in demand by estates some distance from the coast, and also by planters at windward.

The number of budded citrus plants distributed was 3,041. Of these, 2,369 were Washington Navel oranges, 406 grape fruit, and the balance consisted of lemons, sweet limes, and Portugal oranges.

There has been a great falling away in the demand for the rubber plants, Castilloa and Funtumia, only 2,306 plants and 57 lb. of seeds of the former, and 128 plants of the latter having been sent out. On the other hand, there is a growing demand for Para rubber, 1,262 plants having been sold and 6,000 seeds obtained for planters. It is probable that Para rubber will thrive in Dominica. The trees at the Botanic Gardens on the first tapping yielded well. The rubber was sent to the International Rubber Exhibition held in London during September 1908. It was pronounced by experts to be good rubber, and on analysis at the Imperial Institute, showed 93·4 per cent. of caoutchouc.

The grafting of cacao has been followed up, and 393 grafted plants distributed for experiment. Progress is slow, as only one tree in the cultivation at the Station possesses the all-round qualities which are desired in grafted plants.

Two hundred plants are being grown in the gardens, and a number of these will be used as nurseries for propagation by grafting.

The propagation of the best kinds of fruit trees has been continued. During the period under review, 252 grafted mango plants of the best varieties were distributed, sixty-four plants of the highly esteemed mangosteen, and numbers of other well-known fruit trees.

A supply of fresh vegetable seed is regularly maintained at the gardens and sold in small packets to peasants, who in turn keep the local market supplied with vegetables. This is a great boon to small growers, as they can depend on being supplied with good seed practically at all periods of the year. The sale of vegetable seeds averages 600 packets a year.

The Station distributes yearly, large supplies of seeds of various green dressings, bud-wood of standard kinds of oranges, grape-fruit, lemon, etc., and seeds of the various shade trees, spineless limes, papaws, and the several species of coffee.

The average annual distribution of plants from the Dominica Botanic Station has been 61,073 for the period of eight years, 1901-2 to 1908-9.

St. Vincent.

The actual number of economic plants of permanent types such as cacao and nutmeg, distributed during the past three years is much smaller than during the previous three years, nevertheless, the demand for plants, more especially cacao, has been considerable. The decline can be clearly traced to the extension of the Sea Island cotton industry. The following table illustrates this point, and also gives the total number of plants distributed from the Botanic Station during the last five years.

At the Agricultural School a large number of cuttings of select varieties of sugar-cane, and shade trees for cacao have been sent out each year, the number for the last year (1908-9) being 31,200 cane plants and 5,000 cuttings of Madura (*Gliricidia maculata*).

Year.	Economic plants distributed.	Area planted in Sea Island cotton.
1904-5	26,256	small, not known
1905-6	17,543	790 acres
1906-7	10,143	1,533 „
1907-8	5,148	3,200 „
1908-9	5,489	3,000 „

From the Central Cotton Ginnery large quantities of cotton seed have been distributed. This work was undertaken in order to supply planters with reliable selected, and disinfected seed from plants which had given a good yield of first class lint, and also to provide facilities for them to get their own seed treated, at cost price. It was hoped by these means to maintain the quality of the cotton, and also to prevent the spread of insect and fungus diseases.

Season.	Cotton seed sold.	Cotton seed fully treated for planters.	Only selected.	Only disinfected.
1905-6	566 lb.	11,860 lb.	...	...
1906-7	6,110 „	10,990 „	5,941 lb.	940 lb.
1007-8	3,365 „	4,289 „	...	1,879 „
1908-9	566 „	5,933 „	...	108 „
Totals	10,607 lb.	33,072 lb.	5,941 lb.	2,927 lb.

The number of cacao and other economic plants distributed free to allottees on the Land Settlement estates from the Botanic Station during the last three years was as follows: 1906-7, 6,209; 1907-8, 3,325; 1908-9, 5,671.

THE COTTON INDUSTRY IN THE WEST INDIES.

At the Agricultural Conference held at Barbados in January 1909, papers were presented which gave an account of the cotton industry at that time, and covered the period that had elapsed since the preparation of papers on the same subject, for the Conference at Jamaica. These papers were published in the *West Indian Bulletin.*

The following references are to papers relating to the cotton industry which have appeared. These papers give a complete account of the development of the cotton industry, its standing from time to time, and accounts of the pests and diseases which have appeared and the methods employed for dealing with them.

West Indian Bulletin, Vol. IV, pp. 195, etc. General account of the Sea Island cotton industry in United States and prospects for West Indies.

West Indian Bulletin, Vol. VI, pp. 109, 117, 123, and 247; Vol. VII, pp. 30, 153, 171, and 291; Vol. VIII, pp. 173, etc. (Jamaica Conference): Vol. IX, pp. 195-242 (Barbados Conference).

Articles which have appeared in the *Agricultural News* from time to time have given notes of current interest, and the Pamphlet entitled the *A B C of Cotton Planting*, issued by the Imperial Department of Agriculture, gives directions for planting and dealing with the crop. In the Annual Reports of the Botanic Stations, the standing of the cotton industry is summarized each year.

All these, taken together, give a complete history and summary of the Sea Island cotton industry in the West Indies.

The present article is intended to supplement the previous statements and bring the whole matter up to date. The information has been largely supplied by the local agricultural officers in each colony.

At the Agricultural Conference held at Barbados in January 1908, the President included in his address information in regard to the Cotton Industry, which is here given as Table I.

TABLE I.

Year.	Acres.	Yield of lint in pounds.	Estimated value of lint.
			£
1902	...	328,530	7,366
1903	4,000	397,541	9,031
1904	7,600	698,981	26,930
1905	11,238	1,122,800	47,846
1906	13,100	1,577,431	69,092
1907	18,166	2,013,698	172,204

St. Vincent.

The actual number of economic plants of permanent types such as cacao and nutmeg, distributed during the past three years is much smaller than during the previous three years, nevertheless, the demand for plants, more especially cacao, has been considerable. The decline can be clearly traced to the extension of the Sea Island cotton industry. The following table illustrates this point, and also gives the total number of plants distributed from the Botanic Station during the last five years.

At the Agricultural School a large number of cuttings of select varieties of sugar-cane, and shade trees for cacao have been sent out each year, the number for the last year (1908-9) being 31,200 cane plants and 5,000 cuttings of Madura (*Gliricidia maculata*).

Year.	Economic plants distributed.	Area planted in Sea Island cotton.
1904-5	26,256	small, not known
1905-6	17,543	790 acres
1906-7	10,143	1,533 „
1907-8	5,148	3,200 „
1908-9	5,489	3,000 „

From the Central Cotton Ginnery large quantities of cotton seed have been distributed. This work was undertaken in order to supply planters with reliable selected, and disinfected seed from plants which had given a good yield of first class lint, and also to provide facilities for them to get their own seed treated, at cost price. It was hoped by these means to maintain the quality of the cotton, and also to prevent the spread of insect and fungus diseases.

Season.	Cotton seed sold.	Cotton seed fully treated for planters.	Only selected.	Only disinfected.
1905-6	566 lb.	11,860 lb.	...	...
1906-7	6,110 „	10,990 „	5,941 lb.	940 lb.
1007-8	3,365 „	4,289 „	...	1,879 „
1908-9	566 „	5,933 „	...	108 „
Totals	10,607 lb.	33,072 lb.	5,941 lb.	2,927 lb.

The number of cacao and other economic plants distributed free to allottees on the Land Settlement estates from the Botanic Station during the last three years was as follows: 1906-7. 6,209; 1907-8. 3,325; 1908-9, 5,671.

THE COTTON INDUSTRY IN THE WEST INDIES.

At the Agricultural Conference held at Barbados in January 1909, papers were presented which gave an account of the cotton industry at that time, and covered the period that had elapsed since the preparation of papers on the same subject, for the Conference at Jamaica. These papers were published in the *West Indian Bulletin.*

The following references are to papers relating to the cotton industry which have appeared. These papers give a complete account of the development of the cotton industry, its standing from time to time, and accounts of the pests and diseases which have appeared and the methods employed for dealing with them.

West Indian Bulletin, Vol. IV, pp. 195, etc. General account of the Sea Island cotton industry in United States and prospects for West Indies.

West Indian Bulletin, Vol. VI, pp. 109, 117, 123, and 247; Vol. VII, pp. 30, 153, 171, and 291; Vol. VIII, pp. 173, etc. (Jamaica Conference); Vol. IX, pp. 195-242 (Barbados Conference).

Articles which have appeared in the *Agricultural News* from time to time have given notes of current interest, and the Pamphlet entitled the *A B C of Cotton Planting*, issued by the Imperial Department of Agriculture, gives directions for planting and dealing with the crop. In the Annual Reports of the Botanic Stations, the standing of the cotton industry is summarized each year.

All these, taken together, give a complete history and summary of the Sea Island cotton industry in the West Indies.

The present article is intended to supplement the previous statements and bring the whole matter up to date. The information has been largely supplied by the local agricultural officers in each colony.

At the Agricultural Conference held at Barbados in January 1908, the President included in his address information in regard to the Cotton Industry, which is here given as Table 1.

TABLE I.

Year.	Acres.	Yield of lint in pounds.	Estimated value of lint.
			£
1902	...	328,530	7,366
1903	4,000	397,541	9,031
1904	7,600	698,981	26,930
1905	11,238	1,122,800	47,846
1906	13,100	1,577,431	69,092
1907	18,166	2,013,698	172,204

The following notes show the acreage and the results obtained since that time.

TABLE II.

Island.	Year.	Acres.	Average yield per acre in pounds.	Yield of lint in pounds.	
Antigua, including Barbuda ...	1906-7	1,823	104	189,318	
	1907-8	2,658	73	182,180	
	1908-9	800	56	45,310	
St. Kitts	1906-7	1,500	121	180,917	
	1907-8	2,000	130	233,006	
	1908-9	1,500	...	174,301	6 months to June 30, 1909.
Nevis	1906-7	2,000	48	96,402	
	1907-8	1,500	141	211,431	
	1908-9	1,200	...	85,749	6 months to June 30, 1909.
Anguilla	1906-7	1,500	41	61,666	
	1907-8	1,500	72	107,989	
	1908-9	1,200	...	21,520	6 months to June 30, 1909.
Montserrat ...	1906-7	1,050	160	164,340	
	1907-8	2,100	171	360,000	
	1908-9	2,250	106	238,959	
Virgin Islands ...	1906-7	...	...	10,177	
	1907-8	...	...	32,520	
	1908-9	..	...	52,528	
St. Vincent ...	1906-7	1,533	175	225,632	
	1907-8	3,200	135	388,833	
	1908-9	3,000	124	432,091	
Barbados	1906-7	5,000	167	832,408	
	1907-8	7,194	137	988,443	
	1908-9	5,768	119	683,646	9 months to June 30, 1909.

Table II shows the yields and, in most instances, the acreage of Sea Island cotton for the past three crop seasons. The acreage for the Virgin Islands is not available. The cotton is there all grown by peasant cultivators, and it is likely that even an approximate estimate of the area of the cotton lands would be impossible to obtain. In Table I, which shows the amount and value of the Sea Island cotton from 1902 to 1907, the figures are given for the calendar year, but as a crop year has since been generally adopted for convenience, the figures given herewith, are based on the crop year, which in most islands is taken from October 1 to September 30. In Montserrat and St. Vincent however, the crop year includes the period from July 1, to June 30.

As there is likely to be a certain overlap of figures due to the statement of results in different ways, those for 1906-7 are included in Table II, and also in the totals shown in Table III.

The acreage planted in Sea Island cotton, and the lint produced in the islands named during the three crop years 1906-7, 1907-8, and the portion of 1908-9 for which figures are available, are shown by the following table:—

TABLE III.

Years.	Acres.	Yield of lint in pounds.
1906-7	14,356	1,780,856
1907-8	20,482	2,504,442
1908-9	15,715	1,834,103

The increased area planted for the season of 1907-8 was argely due to the very high prices realized for the best grades of West Indian Sea Island cotton during 1906-7. Unfavourable weather, and, in some instances, the attacks of insect pests and plant disease, affected the crop to a considerable extent, and this probably had some influence in reducing the acreage planted for the crop 1908-9. During 1908-9, however, the very low prices and sluggish market, on account of which cotton remained unsold for long periods of time, have caused a further falling off, and the area planted this season for the crop of 1909-10 will probably be much smaller than in the previous year.

It will be seen from an examination of Table II, that the favourable seasons have not occurred in the same years in the different islands. For instance, the crop of 1907-8 represented a larger acreage than that of 1906-7 in every island except Nevis and Anguilla. The reason for the falling off in Nevis was, perhaps, that the weather conditions in 1906-7 were

extremely unfavourable, and in spite of the high prices, many cultivators did not make such satisfactory profits as they had expected, and they consequently turned their attention to other things.

In Anguilla, 1,500 acres represent the maximum area so far planted to cotton, and it is likely that the difficulties experienced in finding labour for the larger cultivations, and capital for the peasant proprietors, will fix the possible maximum at something near this figure.

This table also shows that, in Antigua, the cotton industry has obtained the least secure establishment; and when it is taken into account that the prospect is that only 300 acres will be planted for the crop of 1909-10, it will be realized that a considerable falling off is being experienced.

This is very largely due to the unfavourable weather conditions, and the attacks of the flower-bud maggot. On the other hand, it must be remembered that Antigua has a very efficient central sugar factory, and land which might have grown cotton can readily be turned to cane cultivation.

A contrasting condition of affairs is seen in the Virgin Islands, where the most steady progress and development have been made.

In St. Kitts and Barbados, cotton will continue to remain secondary to sugar-cane, while in several of the other islands it has become the principal crop.

In St. Lucia, the Sea Island cotton industry has not made progress as in most other places. There are several reasons for this. One is, that agricultural labourers are not easily obtained in the districts where, on account of the climatic conditions, cotton would be most likely to succeed. The growing of cacao, sugar, and minor products in certain districts furnishes employment to all the labourers therein, and the peasants of the other districts are mostly fisher folk, or are employed by the commercial industries of the port. A substantial beginning has now been made, however, and a cotton ginning factory has been erected. The total exports for the crop year 1908-9 amounted to 5,500 ℔. of lint, some of which sold at 15*d.* per ℔. There is a prospect that there will be a larger area planted in 1909-10 than in the year just past. A great increase might be expected if the peasantry were to take up cotton growing with the same enthusiasm as has been shown by this class in other places.

In Grenada, cotton has been tried experimentally, but has not become established as a crop of any importance. At Carriacou, on the other hand, it is of great importance. The bulk of Carriacou cotton is of the Marie Galante variety, which has been grown in that island for many years, but the cultivation of Sea Island has greatly increased.

BARBADOS.

BY J. R. BOVELL, I.S.O., F.C.S., F.L.S.,
Superintendent of Agriculture.

During the past two seasons the yield of cotton at Barbados has unfortunately decreased to a considerable extent. For the season 1907-8, 7,194 acres of cotton were planted, from which were obtained 988,443 lb. of lint, or 137 lb. per acre, and 2,368,855 lb. of seed, of the value together of £71,904. Owing to this decreased yield, and to the low prices obtained for the lint, the area was further reduced for the season 1908-9, being only 5,768 acres. From the prolonged drought that obtained during the greater part of 1908 and the beginning of 1909, the yield will probably this season again be low, as only 683,646 lb. of lint, or 119 lb per acre, have so far been obtained for the first nine months of the season, i.e., to the end of the quarter ended June 30, 1909, when nearly all the crop has been picked.

As the decreased yield per acre is to some extent due to the attacks of insect pests and fungoid diseases, an effort is now being made to obtain cotton plants of greater immunity, and of better yielding quality, by means of a series of cotton selection plots, which is now being carried on, not only on lands of the local Department of Agriculture, but also in co-operation with a number of estate proprietors in the island. In addition to these experiments, in which seed from the healthiest and most vigorous plants producing lint of a good quality is retained for planting, a further series of experiments was started in 1908 on lands rented from Waterford plantation. These latter experiments have for their object the crossing of some of the best plants grown from selected Sea Island cotton seed, and from the Silket variety, with plants of the cotton indigenous to the colony, and also plants grown from seed obtained from healthy and vigorous plants found growing in fields in which the majority of plants were either dead or dying. In some instances, the cotton obtained from these plants, although giving heavy yields, was either too short, too coarse, or not strong enough, and it is hoped by crossing these with best Sea Island cotton, to produce plants that are not only greatly immune to the attacks of insect pests and fungoid diseases, but will also give heavy yields of good quality lint.

It is too soon yet to make any definite estimate of the cotton likely to be grown this year in Barbados, but judging from the sale of cotton seed to planters, it is estimated that the area under cotton for the season 1909-10 will be probably something like 2,000 acres less than that for the previous season.

ST. VINCENT.

BY W. N. SANDS, Agricultural Superintendent.

The cotton industry at St. Vincent continues to grow and develop, and the outlook at the present time is satisfactory

The industry is well suited to local circumstances, and chiefly through it, the financial and industrial condition of the colony has much improved.

The quality of the produce is very good indeed, and no other West Indian island appears to possess soil and climate capable of producing Sea Island cotton with the same excellent characteristics. In the English market, St. Vincent cotton fetches several pence per pound more than cotton grown in other islands. It sells readily, and is even preferred by spinners to some of the best Carolina cotton.

The following table, compiled from Customs returns, shows the value of the exports of the past six years, and also the solid and progressive increase in weight of the cotton exported:—

EXPORTS OF COTTON.

Year.	Sea Island cotton in pounds.	Estimated value.	Total exports of Sea Island and 'Marie Galante' in pounds.	Total estimated value.
		£		£
1903-4	not known	...	43,392	794
1904-5	77,814	3,890	126,178	4,494
1905-6	121,174	6,059	138,150	7,674
1906-7	225,632	16,922	263,036	18,169
1907-8	388,838	29,162	427,819	30,787
1908-9	432,091	28,971	459,303	29,878
Total	1,245,544	£85,004	1,457,878	£91,796

Although the total weight of cotton exported last year was 31,484 lb. in excess of the exports of the previous season, the total value, owing to lower prices, was £909 less. It will be seen that the Sea Island cotton exports of the past five years amount to no less than 1,245,544 lb. of an estimated value of £85,004. These figures speak for themselves. It might, however, be mentioned, that during the past two years cotton has taken the premier place in point of value of the island's exports.

It has been found difficult to obtain a correct return of the area planted each season in Sea Island cotton, and of the average yield per acre, but the following table, based on information collected, may be taken as a fairly reliable guide.

The cotton season here is approximately from June 1, to May 31.

Acreage and Yield of Sea Island Cotton.

Year.	Estimated acreage.	Yield in pounds.	Estimated yield per acre in pounds.
1905-6	790	121,174	174
1906-7	1,533	225,632	175
1907-8	3,200	388,833	135
1908-9	3,000	432,091	124

The low average yields of the past two seasons have in no small measure been due to exceptional December rains, together with poor cultivation. The rainfall recorded at the Botanic Station in December 1907, amounted to 12·26 inches, and in the same month of 1908, to 21·81 inches. The heavy rains occurred when the cotton was in full bearing, and a good deal of damage was done. The average December rainfall of the previous five years, 1902-6, was only 6·54 inches.

A good deal more might be done in regard to cultivation. There has been a tendency in the past to underrate the value of organic manures. Efforts have been made to induce planters to devote more attention to crop rotations, to grow larger areas of leguminous plants for green-dressing purposes, and to utilize all available manure, bush, grass, etc., and cotton seed. It has been clearly demonstrated that unless lands for cotton are well cultivated and manured, poor yields result. During the first two or three years cotton was grown, a good area of the land did not require manure—it was rich enough; but now that practically all the available land has grown three or more crops, manure in some form or other is necessary. With low prices, good average yields are of vital importance to the industry. Several examples could be given of the satisfactory financial results of intelligent cultivation even under the somewhat adverse conditions of the past two seasons.

It is proposed to introduce suitable implements at an early date, in order that experiments in mechanical tillage may be undertaken. At the present time practically all cultural operations are performed with the hoe. The deeper and more thorough cultivation, which is likely to result from the use of modern implements, will, it is hoped, lead to greater productiveness, and put the industry on a firmer footing.

Under existing labour conditions, and market prices, it appears that about 3,000 acres represent the area which can be profitably cultivated in Sea Island cotton in St. Vincent.

In the St. Vincent Grenadines, notably, Union, Canouan and Mayreau, the common 'Marie Galante' type is still cultivated; it is grown as a perennial, and produces a short, coarse lint, valued at from *6d.* to *8d.* per lb. The exports

of this cotton during the past five years amounted to 168,942 lb., valued at £5,998. In several of the other islets, e.g., Bequia, Mustique, Battowia, and Balliceaux, the cultivation of Sea Island cotton has been taken up exclusively, and with very satisfactory results. In time, it is hoped that the other islands will fall into line.

Although no actual figures of the cost of production of Sea Island cotton can be given yet, planters are of opinion that they can grow it as cheaply as growers in the Sea Islands of South Carolina. They do not fear competition in this direction provided the industry is not handicapped in any way. At present the prevalence of cotton stealing is a handicap, but a line of action has been proposed, which, when carried out by the Government, will, it is hoped, check the evil.

At the present time thirteen power gins are being worked in the island, eight at the Government Central Cotton Ginnery, three by Mr. C. J. Simmons, and two by Messrs. Mac Donald Bros.

The work of ginning and baling cotton was undertaken by the Imperial Department of Agriculture at the Central Cotton Ginnery when the industry was first started, and has been carried on to date. In 1907-8, 750 bales of 360 lb. net were ginned, and during the past season, 601 bales. A fair profit has been made each year, part of which is now devoted to the upkeep of the local Agricultural Department.

In order to maintain the quality of the lint, the Department has each year selected, tested, and disinfected cotton seed from the best marks for planting, and large quantities have been dealt with. Last year no less than 17,431 lb. were sent out from the Central Cotton Ginnery.

Cotton-plant selection experiments were started by the Department, and continued for two seasons, but were discontinued owing to certain circumstances which it is unnecessary to mention here. This was unfortunate, but the work will be restarted during the coming season. In the interests of the industry it is very desirable that the quality of the local produce should be maintained, and if possible, improved; also that plants giving better yields, and more resistance to insect and fungus attack should be found. It is thought that cotton-plant selection experiments will in time lead to this result. A few planters do, however, carry on plant selection on modified lines, and propagate good types in nurseries. So far, not much deterioration has been observed; this is probably due to the fact that the plant has not been cultivated over a long period under local conditions. Being a highly selected, and unstable variety, it will surely revert unless careful selection on scientific lines is carried out. It is fortunate that the soil and climate are favourable, otherwise, long ere this, rapid reversion would have taken place, as has been the case in other islands.

Cotton growers here have been specially favoured in not having to take expensive measures for the control of the cotton worm (*Aletia argillacea*). This worm, which is such a serious pest in other islands, and costs planters so much to keep in check, has not yet done much damage. It was found

in all districts but natural enemies appear to have kept it in check. The leaf-blister mite (*Eriophyes gossypii*), and the black scale (*Lecanium nigrum*) have been responsible for some loss, but as energetic measures have been taken at the end of each crop, and most planters have been induced to pull up and burn the cotton stalks, the damage done has not been serious, and only towards the end of the season have these pests got the upper hand. Fungus diseases such as anthracnose, rust, and mildew have caused considerable loss each season. A comprehensive series of experiments has been carried on during the past two years at the Agricultural School in order to ascertain if these fungi can be controlled. These experiments are being continued, and it is too early yet to publish results, but it might be mentioned that, so far, no very important conclusions can be drawn. In these experiments an effort is being made to test the effect of planting at different distances, the application of various fungicides, and of potash and phosphatic manures.

The heavy rainfall of the island of course favours the growth of destructive fungi. It may therefore be of interest to give a table showing the average monthly rainfall during the growing season. The records were taken at the Botanic Station, and represent the average of the past eight years.

Month.	Average monthly rainfall Inches.
June	12·24
July	11·45
August	12·63
September	10·62
October	11·51
November	9 51
December	10·75
Total ...	78·71

Average monthly rainfall ... 11·24 inches.

In all districts, except the Grenadines, the rains are heavy during the abovenamed months, and one can readily see that with an average monthly rainfall of about 11·24 inches, the control of fungus diseases would be difficult. Provided the lands are well selected and cultivated, and the plants properly thinned and spaced, good average crops can be produced, notwithstanding the presence of these diseases. Sea Island cotton requires a light soil and a moist climate, and it is only under these conditions that the finest quality of lint can be grown.

So far, cotton has been cultivated chiefly on estates, but the peasantry are now taking to the industry, especially those owning or working lands near the coast. No large extension of planting, either on the part of estates, or of the peasantry, is however anticipated at the present time.

ANTIGUA.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S.,
Acting Government Chemist and Superintendent of Agriculture for the Leeward Islands.

The history of the cotton industry in Antigua, from 1908 to the present time, covers a period of set-back, the effects of disease, bad seasons, and low prices having combined to administer a check to the industry. For the planting season of 1907-8, 2,508 acres of cotton were planted, this being the largest area to which the cotton industry in Antigua had attained. During the earliest portions of the growing season, prospects seemed good for a satisfactory return. In December 1908, the flower-bud dropping, due to the maggot of a small fly, (*Contarinia gossypii*), became recognized as a pest and assumed serious proportions. As a result of its attack, the total crop of cotton reaped from the area above given, fell far short of expectation. The total yield was 182,180 ℔., or an average of 73 ℔. of lint per acre.

The following season the area planted in cotton was estimated at 800 acres. The earlier part of the growing season was extremely unpropitious; bad seasonal conditions rendered the establishment of the crop exceedingly difficult. This was followed by the reappearance of the flower-bud maggot disease, and phenomenally heavy rain in December, all of which served to give a further check to the industry. Only 45,310 ℔. of lint have been shipped—an average of 56 ℔. to the acre. Added to this, market prices have been low, and difficulty has been experienced in disposing of the crop.

It appears likely that the area to be cultivated during the coming growing season in Antigua may amount to about 300 acres, and it is hoped that conditions may this year prove more favourable and that better returns may be obtained.

The rapid increase in the acreage of cotton cultivation resulted in a correspondingly rapid increase of pests and diseases, and these, with abnormal weather conditions, have been responsible for their more recent rapid decrease. It is hoped that with a smaller acreage there will be a tendency towards the restoration of the balance of nature, and that if more normal and favourable seasons are experienced, the cotton industry may be put on a firm and profitable basis.

ST. KITTS, NEVIS AND ANGUILLA.

BY F. R. SHEPHERD,
Agricultural Superintendent.

The area of cotton planted in the Presidency for the season 1907-8 was 5,000 acres, 2,000 of which were in St. Kitts, and 1,500 each in Nevis and Anguilla. For the season 1908-9, owing to the fall in prices, this area was reduced to about 4,000 acres: 1,500 in St. Kitts, 1,200 in Nevis, and about 1,200 in Anguilla.

In St. Kitts, for 1907-8, the return of lint per acre over the island was not more that 130 ℔., but individual estates produced a much larger yield, in some instances over 300 ℔. lint per acre, over areas of 50 acres.

The quality of the lint was good, and the earlier prices were very satisfactory; but towards the close of the year they began to fall and, since then, the average price has been from 13½*d.* to 14*d.* per ℔.

The season 1908-9 was not so favourable for cotton growing, and in many parts of the island the rainfall towards the end of the year was so heavy that the yield was very much reduced. The total returns are not yet to hand, but it is evident that the yield per acre will be lower than in previous years. This result, with the fall in price, will tend to reduce the acreage planted for the coming season 1909-10, which is hardly likely to exceed 1,200 acres.

The cotton worm and other pests have not been so troublesome during the period under review, and more intelligence is displayed in dealing with them.

Manurial experiments on cotton have been continued at the experiment plots at La Guerite on similar lines as in previous years.

Cotton selection experiments have been successfully carried on at La Guerite, and the results obtained from the examination of the cotton grown from the seeds selected from individual trees in 1907 have been most encouraging. These experiments are being extended in the coming season, and it is hoped that a strain of cotton will be produced suitable for local conditions.

The same three ginneries have been at work—one at Spooners', with an oil plant, one at Stone Fort, and one in Basseterre.

On the whole, the condition of the cotton industry in St. Kitts, although not quite so encouraging at the present time, causes no fear that the area will be reduced very greatly, because cotton can be grown as an 'intermediate' crop with cane, and the estates are the chief growers. At the present time (June 1909) the weather is so dry that hardly any cotton has been planted, and if this continues much longer the area may be affected, as then it will be too late to plant before the cane crop.

In Nevis, in the season 1907-8, the returns were greater than the previous year, notwithstanding the reduced acreage. This was due to improved methods of cultivation, the more intelligent care taken of the cotton when growing, and in dealing with the various pests. This has been the result of the work of the Agricultural Instructor, who has devoted much time and attention to affording information to the small growers and others.

The season of 1908-9 was most unfavourable for cotton growing in Nevis. The gale in September did much damage, and this, followed by the heavy rainfall in the latter part of the

year, caused a large proportion of bolls to drop. In consequence, the returns, except in one or two special cases, have been very low, and it is thought that the output would be very small, not averaging 100 lb. lint per acre.

Special attention was paid to providing selected and disinfected seed, from the best local sources, for the small growers at moderate prices, and the result has been most encouraging. This has been continued for the coming season.

The ginneries at the Nevis Ltd., with an oil plant attached, and at Stoney Grove and Charlestown have been at work. Some 45,000 lb. of lint from St. Kitts was ginned at the ginnery of the Nevis Ltd., it being found cheaper to take it there by boat, than to cart it to the ginnery at Spooners, in St. Kitts.

Two acres of land were rented near the experiment station, and cotton demonstration plots were laid out to ascertain the manurial requirements of the cotton plant in Nevis, and also to try improved methods of cultivation, etc. The results from these plots, owing to the unfavourble weather conditions, have not been satisfactory or remunerative, and a further trial is being made in the coming season on the same lines.

The cotton industry in Nevis during the past two years has not been remunerative, except in a few instances. This is owing to unfavourable weather conditions and the fall in prices. For these reasons it is probable that there will be a considerable reduction in the area planted during the coming season, especially among the small growers, who seem inclined to return to cane cultivation, it being a more reliable crop under conditions prevailing in Nevis.

In Anguilla the season of 1907-8 was most favourable for cotton, and the return of lint was the largest yet obtained, the total shipments amounting to 107,989 lb. lint. The reduction in price, however, caused a tendency among the small growers to reduce the acreage planted, and so that for 1908-9 was about 300 acres less than the previous year.

The general weather conditions of the past season were most unfavourable, and the returns, in consequence, have been very small. This, added to the fall in price, will tend further to reduce the acreage planted; but cotton being the only crop of any value that can be grown in Anguilla, it is not likely that the shortage will be very great. The only ginnery in Anguilla is owned by Mr. C. Rey, who by making advances to, and purchasing the cotton of, the small growers has done much to advance the cotton industry in the island. Mr. Rey himself is being assisted by the local Government and the British Cotton Growing Association with advances, which enable him to give this much needed help to the small growers.

The following table gives the amount of lint exported from the Presidency for the crop year fr m Oct. 1, 1907, to Sept. 30, 1908, and from Oct. 1, 1908, to March 31, 1909, the figures for the quarter ending June 30 not being yet available:—

	1907-8.	Oct. 1, 1908, to Mch. 30, 1909.
	Yield of lint in pounds.	Yield of lint in pounds.
St. Kitts	233,006	174,301
Nevis	211,431	85,749
Anguilla	76,200	21,520
Total	520,637	281,570

VIRGIN ISLANDS.

The accompanying table showing the weight and value of cotton shipped from the Virgin Islands each year since 1904 has been supplied by the Agricultural Instructor, Tortola:—

Year	Quantity of lint shipped, in pounds.	Value.	Increase over previous year	
			Lint in pounds.	Value.
		£		£
1904	1,250	35		
1905	4,000	145	2,750	110
1906	7,807	265	3,807	120
1907	10,177	620	2,370	355
1908	32,520	1,800	22,343	1,180
1909	52,528	2,520	20,008	720
Total	108,282	£5,385		

MONTSERRAT.

BY W. ROBSON, CURATOR, BOTANIC STATION.

The area planted in cotton for the season 1908-9 was about 2,250 acres as compared with 2,100 acres in the previous year. The increase can be attributed to development amongst the small cultivators, who had 400 acres in 1907-8, and 520 in the past season.

The crop season was a very unfavourable one and the total exports of lint amounted only to 238,959 lb., of a value of £12,000 (approximately).

The land was prepared early, and practically the whole of the crop was established by the end of July. As in previous years, the destruction of the plants from the preceding season's crop was very generally carried out. The seed used for planting was all produced in the island, but was disinfected. This was done by the estate managers.

The outlook for the crop was bright until towards the end of September, on the 25th of which month a very severe gale swept over most districts of the island, uprooting large numbers of the cotton plants, and whole areas were destroyed. Following on the gale was a prolonged drought, and this killed out large numbers of plants, which might have recovered if rains had fallen. The northern and windward districts suffered most. The crop came in early and the greater portion was picked previous to the New Year. The prospects for a second crop were good at one time, but this ultimately proved disappointing. The Montserrat crop as a rule is picked before the end of March, and good cotton is never reaped in any quantity after that date. This probably explains why we are so successful in getting rid of the old plants before re-planting.

The adverse weather conditions no doubt encouraged the spread of the leaf-blister mite, which was more prevalent than for some years past, and much of the later growth was rendered useless through its attacks.

Of other pests, the cotton worm was not more troublesome than usual, but the flower-bud maggot which had been noticed in a few cases in the last season was, in the months of February and March, found in most districts of the island. If this appearance so late in the season is characteristic of the insect (as is the case with the cotton stainer), the Montserrat cotton crop is not likely to suffer severe injury from it.

By planting early, May and June, cotton growers usually get their crops well assured before the end of the year.

The prices received for lint ranged from 1*s.* 0½*d.* to 1*s.* 2*d.*, during the season. The depressed state of the market together with the small crop reaped last year combine to check the further extension of the industry for the present, and it is not likely that so large an area will be put in for the coming season.

The cotton grown by the peasants, 800 of whom grew plots varying in size from $\frac{1}{10}$ to 5 acres in area was bought locally. The peasants' crop amounted to 200,719 lb. of seed-cotton, which at 4c. a pound gave £1,672.

Seed selection does not receive the attention of planters that it deserves. In June 1908, about 130 lb. of cotton seed from pedigree stock was distributed to various estates in the island. Part of this was of the Rivers' type and the remainder Gilbert's. Four acres of the former was planted on Dagenham and yielded 450 lb. of lint per acre.

Another acre of the same seed, planted at Parson's, yielded 250 lb. per acre, and 4 acres of the Gilbert's planted at Trants gave 300 lb. of lint per acre.

Selection plots are being continued at the Botanic Station, and in the past season special plants selected for their high yielding qualities, as well as on the merits of the lint, have been retained of Gilbert's, Stirling, and Rivers' types.

THE ESTIMATION OF WATER IN MOLASSES.

BY R. R. HALL, B.A.,

Acting Island Professor of Chemistry, Barbados.

The following is an account of analyses of eight samples of vacuum-pan molasses obtained from seven sugar factories in the island. Samples Nos. 2 and 3 are from the same factory.

These analyses were undertaken with a view to testing whether Heron's method and correction for estimating water in molasses were applicable to Barbados vacuum-pan molasses.

The various constituents were determined as follows:—

The water, by mixing the molasses with powdered glass and drying at 100° C. in vacuo.

The glucose (invert sugar), by Fehling's volumetric method, Soxhlet's modification.

The saccharose, by inversion with hydrochloric acid, estimating the total invert sugar by Fehling's method as above, subtracting the invert sugar already found and calculating the difference to saccharose.

The ash, by sulphation, igniting at low red heat and subtracting one-tenth.

The organic matter, by difference.

The results obtained are shown in Table I.

The estimation of the water, using Heron's method and correction, was as follows:—

Twenty grammes of molasses were dissolved in water and made up to a volume of 200 c.c. The Brix degree of this solution was taken with a Brix spindle (graduated in tenths of a degree to read correct at the laboratory temperature) and was converted to specific gravity reading according to Douglas' tables; $\frac{18}{20}$ of 0·8* of the sulphated ash was subtracted from the figure so obtained, water being taken as 1,000; the resulting figure multiplied by the corresponding Brix degree according to Douglas' tables: and the product multiplied by $\frac{100}{10}$. This gives the organic solids per cent. To this figure add the ash and subtract the sum from 100; the result is the percentage of water.

* The factor 0·8 is used in compensating for the difference between the effect of the sugar and that of the soluble ash constituents on the specific gravity. (Ed. *W.I.B.*)

TABLE I.

MOLASSES AS ANALYSED.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Water (by direct drying)	25·37	25·19	31·78	30·41	25·59	29·16	28·88	24·81
Saccharose ...	43·82	39·92	36·86	26·11	40·55	28·18	38·43	34·94
Glucose (invert sugar)	9·81	11·51	11·10	23·23	11·55	21·05	12·63	23·76
Ash	6·96	6·40	7·30	4·27	6·41	5·42	5·98	3·74
Organic matter (by difference) ...	14·04	16·98	12·96	15·98	15·90	16·19	14·08	12·75
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Total sugar expressed as glucose .	55·93	53·53	49·90	50·71	54·23	50·71	53·08	60·53
Specific gravity	1·431	1·427	1·372	1·376	1·418	1·393	1·396	1·421

TABLE II.

COMPARISON OF PERCENTAGES OF WATER OBTAINED.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Specific gravity 10 per cent. solution ...	1·0286	1·0294	1·0258	1·0270	1·0294	1·0274	1·0278	1·0290
Water by Heron's method...	25·29	22·43	33·05	26·14	22·42	26·56	26·00	20·35
Water by direct drying (see Table I)	25·37	25·19	31·78	30·41	25·59	29·16	28·88	24·81
*Calculated water ...	24·32	25·20	31·88	31·19	26·06	29·35	28·55	24·22

In sample No. I only does the figure for water obtained by Heron's method agree with that obtained by direct drying; in the other samples the figures are widely different.

* 100 − [Saccharose + Glucose + (apparent Solids not Sugar × ·78.)]

It was suggested that there might be some relation between the apparent and the true non-sugar solids, the apparent non-sugar solids being obtained by subtracting the saccharose and invert sugar from the apparent total solids (Brix degree) of the sample. The figure representing the relation in each of the eight samples is given in Table III. The mean of these figures is 0·78. This figure was used to estimate the percentage of water as follows: The apparent non-sugar solids was multiplied by 0·78, the saccharose and invert sugar added, and the sum subtracted from 100. The figure representing the percentage obtained by this method in each sample is given in Table II under the head 'Calculated Water', where it may be compared with those obtained by Heron's method and by direct drying.

TABLE III.

RELATION BETWEEN APPARENT AND TRUE NON-SUGARS.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Apparent total solids (Brix)	81·9	81·4	73·8	74·3	89·1	76·7	77·2	80·6
(a) Apparent solids not sugar	28·27	29·97	25·84	24·96	28·0	27·47	26·14	21·90
(b) True solids not sugar	21·00	23·38	20·26	20·25	22·31	21·61	20·06	16·49
Ratio $\frac{b}{a}$	0·743	0·780	0·784	0·811	0·797	0·787	0·767	0·753

THE TREATMENT OF SOILS IN 'ORCHARD' CULTIVATION IN THE WEST INDIES.

The object of the following article is to collect, and bring up to date, information that is available with respect to the results obtained from the application of grass and weeds to orchard soils in the West Indies.

The subject was first introduced for consideration by Dr. Watts in a paper read at the Agricultural Conference, 1901; this paper may be found in the *West Indian Bulletin*, Vol. II, p. 96. It has special reference to the kind of treatment which should be given to the soil under cacao, when the trees have reached such a size that crops such as tannias, yams, cassava, and sweet potatos can no longer be grown under them. It is stated that the usual course was, in a few cases, to allow grass to grow between the trees and then to pasture cattle upon it. In other cases, the soil was cultivated to a certain extent by forking the land between the trees, by breaking up the surface with a mattock, or by weeding. Further, the utilization of the spaces between the trees as a pasture for cattle was now almost entirely abandoned, as it was found to cause damage to the trees and soil by the cattle themselves—the former by the direct interference of the cattle, and the latter by their treading the soil into a compact mass. Forking between the trees was useful until the roots and branches have extended into the space allotted to them, but after this, unless great care is taken, these may be seriously injured, especially where the soil is dry and not very fertile. Injury also resulted from the use of the hoe, for, although the weeds are removed by its employment, the surface of the soil is made hard and compact, and the level of the latter near the trees is lowered, so that they eventually stand in hollows. Dr. Watts had noticed in some cases that where moisture was abundant, and where weeds consequently grew easily, it was a common practice to cut them down with a cutlass, without any breaking-up of the soil, and to leave them on the surface, the excuse being made that this was the only method available in view either of the scarcity of labour or of the need for economy.

Observation, however, had led Dr. Watts to conclude that this method had no need of excuse, but was rather to be recommended under certain circumstances, notably where the rainfall was abundant. The chief reasons for this conclusion are best given in Dr. Watts's own words, which are taken from the paper referred to above: 'By such a method, the soil, though quite untilled by implements, remains in a good state of tilth; the roots of the weeds which are killed when the plants are cut down, form air spaces reaching to a considerable depth of the soil; and the earthworms, usually present in abundance in places thus treated, are active agricultural allies. The weeds, spread over the surface, form an excellent mulch, conserving moisture and adding steadily to the store of humus. Indeed, by such a method we approach very nearly to the natural conditions prevailing in a coppice or young forest, where we have the conditions which go to the formation of

virgin soil.' In practice, it was suggested that, in the case of young cacao, as soon as the cultivation of intermediate crops had ceased, the fork may be used until the roots of the young trees began to occupy the soil, and that, then, the periodical growing and cutting of the weeds could be commenced. Thus, in addition to the advantages already stated, there would be the provision of a medium fitted for the undisturbed development of the fine roots of the trees, so that these would become effective in binding the soil together and, in this way, preventing loss by washing during heavy rains. There was no need to confine the plants which were allowed to grow in this way to the naturally occurring weeds, but nature may be aided to a certain extent by controlling the character of the undergrowth and, in this connexion, recourse would obviously be had to leguminors plants.

In the discussion that followed the reading of the paper, there was divergence of opinion as to whether thorough surface cultivation, or the method suggested, was the better system. The subject was followed up by an investigation, which was conducted in Dominica by Dr. Watts and Mr. J. Sowray, with a view to ascertaining the manurial value of weeds in young orchards such as those of cacao and limes. An account of what was done in this connexion appeared in the *West Indian Bulletin*, Vol. V, p. 287, and of this the following is a summary. The weeds normally growing on an area of 225 square feet in a young cacao plantation were collected, weighed, allowed to dry, and weighed again, after which they were found to have lost 33·6 per cent. of their weight. An analysis of the air-dry material gave the following results:—

Constituent.	Percentage.	Weight per acre.
Moisture	10·83	...
Nitrogen	0·74	70·8 lb.
Phosphoric acid (P_2O_5)	0·22	21·1 „
Potash (K_2O) ...	0·99	94·8 „
Total ash	10·33	...

The figures in the third column give the weights of the chief manurial constituents in the weeds that are contained in the weight of them that would be yielded by an acre of ground. The matter may be expressed differently by saying that the quantity growing on that area would contain as much nitrogen, potash, and phosphoric acid as there are in about 334 lb. of sulphate of ammonia, 171 lb. sulphate of potash, and 1 cwt. of basic slag, respectively. These, of course, would not be added to the soil by the return of the weeds which grew on it; they are periodically given back to it by the cutting down of the weed crop from time to time. It must not be forgotten, however, that the continual addition of organic matter to the soil must be of great benefit. In advocating such a system, Dr. Watts stated that it is essential to take care to prevent the formation of anything like a turf; if there is danger of this, the soil should be lightly forked. No figures are available for the purpose of demonstrating the result when the grass and weeds were replaced by a leguminous crop, though it was stated by Dr. Watts at the same Conference, that woolly pyrol (*Phaseolus Mungo*) had been found useful.

Experiments, begun at the Dominica Botanic Station by Dr. Watts and Mr. Joseph Jones, Curator, initiated another phase of the subject. Particulars of these will be found in the Dominica Botanic Station reports, 1902-3 to 1908-9, and in the *West Indian Bulletin*, Vols. VI, pp. 258-62; VII, pp. 201-6; VIII, pp. 131-6; IX, pp. 138-43. In them the principle of treating cacao orchards with grass and weeds was extended by using for the purpose not only those plants which had grown beneath the trees but, in addition, grass and leaves which formed the sweepings of the lawns at the Botanic Station. Before proceeding to the consideration of the results of such experiments, it will be convenient to review the subject of mulching in orchards generally.

In temperate climates, the chief objects in providing a mulch in orchards are to conserve the soil moisture, and to protect the trees from the effects of frost. The first of these is also an important consideration in the tropics where, of course, the loss from the soil by evaporation is greater. The effect of using mulches for the purpose of lessening this loss may be illustrated by reference to some experiments which were carried out in the United States in Wisconsin. In these a dust mulch was used, instead of a vegetable one, but this makes no difference in the matter under consideration, as the general principle is under review. Three different kinds of soil (see Table I) were uniformly packed into iron cylinders 22 inches deep and $\frac{1}{10}$-square foot in area, each of which had a water reservoir at the bottom; the height of the soil column was 19 inches. Water was added to the soil in the cylinders until it was nearly saturated, and a soil mulch, made by crumbling soil of the same kind, was placed on the surface. Reference to the table given below will show that there were five experiments, one in which no mulch was employed, and four in which the thickness was from 1 inch to 4 inches. Ten cylinders were used in each experiment, and the whole lot was subjected to three different sets of conditions: in the first they were placed in a case and airwas drawn over them; in the second, the conditions were the same, but the air was drawn over the soil more slowly; in the third, the cylinders were placed out of doors and exposed to the sun and air. The mean rates of loss of water, reckoned by weight and as rain, per 100 days, are shown in Table I. Nothing more need be said than that this table shows well the effectiveness of mulching, and that this effectiveness increases with the depth of the mulch, up to a certain point, at any rate.

Another form of conservation which the employment of grass and weeds in the way indicated effects is that of humus. This, as is well known, is of special importance in the tropics where, at the high temperature which obtains, bacterial life shows its greatest activity and, consequently, where the changes in the soil content are effected most rapidly. On the presence or absence of humus depends the 'condition' of soil, that is its fitness for the successful growth of roots in it. Observation has shown that new roots are readily formed where there is a large quantity of vegetable matter between cacao trees. Lastly, there is a third kind of conservation, that of the soil itself. Where the rainfall is heavy and the cultivated slopes

TABLE I.

EFFECT OF MULCHING ON CONSERVATION OF SOIL MOISTURE.

	Black marsh soil.		Sandy loam.		Clay loam.	
	Loss of water per acre, in tons.	Equal to rain, in inches.	Loss of water per acre, in tons.	Equal to rain, in inches.	Loss of water per acre, in tons.	Equal to rain, in inches.
No mulch ..	620·9	5·48	724·1	6·54	1,779·6	14·83
Mulch 1 in. deep	367·0	3·24	397·1	3·51	1,249·6	11·03
Mulch 2 in. „	274·3	2·42	288·8	2·55	1.029·2	9·09
Mulch 3 in. „	248·9	2·11	269·2	2·38	974·6	8·61
Mulch 4 in. „	213·8	1·89	251·8	2·22	881·6	7·78

are steep, the soil is washed away wherever there is a heavy downpour of rain. The presence of a thick 'mat' of vegetable débris on the surface of the soil breaks the force of the water falling upon it, and greatly lessens the washing of particles to the lower levels; while, in addition, many of those which are being carried away are arrested in the soil-covering lower down.

A fourth result of the presence of a mulch in orchards will be to prevent the heating of the soil by the direct rays of the sun, except, of course, where this is already effected by shading. Numbers of experiments by different investigators have shown that there is, for every plant, a temperature at which it grows best, and that fluctuations of temperature may, if of sufficient magnitude, render growth slower. Another consideration arises from the fact that the beneficial soil bacteria cannot exist where there is little or no protection from strong, direct sunlight. An illustration of the effectiveness of mulching in keeping the soil temperature from becoming so high as possibly to injure the plants growing in it is given in the *Bulletin of Agricultural Information* of the Trinidad Department of Agriculture, July 1909, from which Table II is taken. The observations were made on soil, with a steep slope and an eastern exposure, on which no plants were growing. Reference to the table, which is compiled from a large number of observations, will show that a fairly thick vegetable mulch is useful for the purpose; that, as would be expected, the effectiveness of the mulch increases with its thickness, and that such a mulch has more protective influence than the first 3 inches of soil.

TABLE II.

EFFECT OF MULCHING ON TEMPERATURE OF SOIL.

	6 a.m.	noon.	6 p.m.
Temperature of surface of soil below fairly thick mulch	73·4	82·0	74·3
Temperature of surface of soil below very thick mulch	...	78·0	73·4
Temperature of soil 1 inch below surface under fairly thick mulch ...	71·0	78·0	73·5
Temperature of bare soil 1 inch deep	71·0	88·0	77·0
„ „ „ „ 3 inches „	...	83·0	78·0
Temperature of soil where earthworms are working — 1 inch deep	72·0	81·0	75·0
Temperature of soil where earthworms are working — 3 inches „	73·0	77·0	75·0

The last important result of keeping a soil well supplied with vegetable matter that may be considered is that of the provision of plant food. This addition will, of course, only take place where plants grown elsewhere are placed on the land, or where leguminous plants are raised. One of the effects of a large amount of humus in the soil is the encouragement of earthworms, and the consequent tillage which is the result of their presence; the lower portions of the soil are brought to the surface by them, and are thus exposed to the action of the weather. This, however, is not the only way in which the food that is locked up in the soil is rendered available. The compounds formed in humus have the power of uniting with part of the mineral substance in the soil, and of thus hastening the processes by which it is brought into a state in which it can be utilized by growing plants.

Such theoretical considerations are borne out in nature and in practice. Where mulching with vegetable matter has been carried on for some time, the state of the soil beneath the trees very much resembles that in virgin forests. That this state is of benefit to the plants growing in such a soil is a natural conclusion, and the correctness of it is borne out by the fact that the removal of dead leaves from forests has been proved to result in injury. In temperate climates the practice under consideration, that of cutting the grass in orchards between the trees and allowing it to lie where it falls, or of spreading vegetable matter on the land, has been found to give, in the case of such plants as apple and plum trees, increased returns with a better quality of fruit. In a tropical climate, that of the Federated Malay States, such a practice is strongly recommended by Mr. J. B. Carruthers (Assistant Director of Agriculture, Trinidad) on account of his experience there, rubber-yielding plants being the ones benefited in this case.

These general considerations must now give place to that of the particular one with which it is the purpose of this article to deal. The experiments conducted by Dr. Watts and Mr. J. Jones at the Dominica Botanic Station were commenced in 1900, but it was not until the season 1902-3 that arrangements were made for recording the results. Five plots, having a total area of rather more than 1½ acres, and on which cacao trees ten years old were growing, were chosen. The number of trees had subsequently to be increased in order that the ground should be well covered. The extent to which this was done, as well as the area of each plot and the manurial treatment given to it, is shown in Table III, which is taken from the Dominica Botanic Station Report, 1907-8.

TABLE III.

PARTICULARS OF MANURIAL PLOTS FOR CACAO.

No.	Number of bearing trees per plot.		Area of plot in acres.	Present number of trees per acre.	Manurial treatment.
	in 1900	in 1907			
1	34	50	0·28	178	No manure.
2	37	45	0·29	155	Basic phosphate 4 cwt. per acre. Sulphate of potash 1½ cwt. per acre.
3	40	50	0·36	139	Dried blood 4 cwt. per acre.
4	34	36	0·29	124	Basic phosphate 4 cwt. per acre. Sulphate of potash 1½ cwt. per acre. Dried blood 4 cwt. per acre.
5	39	40	0·37	108	Mulched with grass and leaves.

Naturally, the smallest trees are those on the plots containing the greatest number, for the additional ones have been introduced in order to complete the cover. Reference to the tables given below (Tables IV and V) will show that the largest trees have given the greatest yields of cacao per tree and per acre, demonstrating that the increased growth of the tree has not led to a diminution of its fruiting capacity. The produce of the added trees was not taken into account in the results until the season 1906-7—a circumstance which accounts for the apparent falling off in the yield per tree on some of the plots during that year. The application of the manures and the

mulch takes place once a year ; the former are distributed and slightly stirred in, while the latter is simply spread evenly over the ground. The weight of vegetable matter received by each tree is about 80 lb.; it consists of grass, leaves, and the leaves and pods of the Saman, or Guango (*Pithecolobium Saman*), and is therefore richer in nitrogen than grass and leaves alone.

The results are given in Tables IV, V, VI and VII, which are either taken or compiled from the Dominica Botanic Station Report for 1907-8. They are based upon the year ending June 30, as in this way, confusion of the records by the inclusion of the products belonging to two different crops is obviated. The weights of cured cacao are arrived at by taking 42 per cent. of the wet product.

TABLE IV.

YIELD OF WET CACAO PER TREE AND PER ACRE, 1902-8.

Year.	Plot 1. No Manure. Yield in pounds.		Plot 2. Phosphate and potash. Yield in pounds.		Plot 3. Dried blood. Yield in pounds.		Plot 4. Dried blood, phosphate and potash Yield in pounds.		Plot 5. Mulched with grass and leaves. Yield in pounds.	
	per tree.	per acre.	per tree.	per acre.	per tree.	per acre.	per tree.	per acre.	per tree.	per acre.
1902-3	22·3	2,711	28·7	3,660	32·2	3,558	32·4	3,807	29·3	3,095
1903-4	16·1	1,957	21·8	2,780	24·3	2,694	21·7	2.545	24·6	2,600
1904-5	19·8	2,403	22·0	2,807	24·3	2,694	28·8	3,376	32·8	3,187
1905-6	22·0	2,672	20·1	2,631	26·4	2,933	30·6	3,586	38·9	4,105
1906-7	14·6	2,607	19·7	3,050	19·4	2,700	28·0	3,479	38·4	4.151
1907-8	18·1	3,225	25·8	4,000	27·6	3,836	32·8	4,069	44·3	4,792

Consultation of Tables IV and V will show that the beneficial effects of mulching which have been realized for several years continue to be felt. Not only this, but it will demonstrate that far better yields have been obtained by it than by the application of artificial manures. The yield of cured cacao per acre has increased from 1,300 lb. in 1902-3 to 2,012 lb. in 1907-8, making an increased yield, after six years, of 712 lb. on the plot that has received vegetable débris (No. 5), while this increase in the best of the manured plots, namely that which received dried blood, phosphate and potash, was from 1,599 lb. to 1,709, making an increase for the same period

TABLE V.

YIELD OF CURED CACAO IN POUNDS PER ACRE, 1902-8.

Year.	Plot 1. No Manure.	Plot 2. Phosphate and potash.	Plot 3. Dried blood.	Plot 4. Dried blood, phosphate and potash.	Plot 5. Mulched with grass and leaves.
	Yield per acre in pounds.	Yield per acre in pounds.	Yield per acre in pounds.	Yield per acre in pounds.	Yield per acre in pounds.
1902-3	1,138	1,540	1,491	1,599	1,300
1903-4	822	1,170	1,132	1,069	1,092
1904-5	1,009	1,179	1,132	1,418	1,338
1905-6	1,122	1,105	1,231	1,506	1,724
1906-7	1.095	1,285	1,134	1,461	1,743
1907-8	1,354	1,680	1,611	1,709	2,012
Total for six years	6,540	7,950	7,732	8,762	9,209
Average for six years	1,090	1,326	1,289	1,460	1,555

TABLE VI.

MONETARY GAIN FROM MANURING. AVERAGE OF SIX YEARS.

Plot.	Average annual yield per acre of cured cacao during six years.	Gain in dry cacao per acre over no manure.	Value per acre of increase over no manure at 6*d*. per lb. of cured cacao.	Cost of manure per acre.	Gain per acre by manuring.
	lb.	lb.	s. d.	s. d.	s. d.
1	1,090	...	...	...	...
2	1,326	236	118 0	45 3	72 9
3	1,289	199	99 6	36 0	63 6
4	1,460	370	185 0	81 3	103 9
5	1,555	465	232 6	60 0	172 6

TABLE VII.

MONETARY GAIN FROM MANURING. RESULTS OF ONE YEAR.

Plot.	Yield per acre of cured cacao, 1907-8.	Gain per acre over no manure.	Value per acre of increase over no manure.	Cost of manure per acre.	Gain per acre by manuring, 1907-8.
	lb.	lb.	s. d.	s. d.	s. d.
1	1,354	...	...	...	...
2	1,680	326	163 0	45 3	117 9
3	1,611	257	128 6	36 0	92 6
4	1,709	345	172 6	81 3	91 3
5	2,012	658	329 0	60 0	269 0

of 110 lb. The total yield per acre in these cases was 9,209 lb. and 8,762 lb., respectively, making an average yearly yield of 1,555 lb. and 1,460 lb. These returns are not, of course, complete, unless the cost of the manure and that of collecting and applying the mulch are taken into consideration. This has been done, and the results appear in Tables VI and VII. Taking, as before, the best of the manured plots alone for the purpose of comparison, it is seen that the annual cost of mulching and manuring, allowing a liberal estimate for the former, has been £3 and £4 1*s.* 3*d.* These expenses correspond with average yields of cured cacao (over those from the plot without manure) to the value of £11 12*s.* 6*d.* and £9 5*s.*, making a monetary gain per acre, in the same manner, of £8 12*s.* 6*d.* and £5 3*s.* 9*d.* In this way, during six years, the mulched trees have been more than one and a half times as valuable (as regards net proceeds) as the manured trees, as far as average annual yield is concerned. When figures are taken in a similar way for the last of the years under discussion, namely 1907-8, they are still more striking. In this case the gain (over no manure) by mulching has been one of £13 9*s.*, and by manuring, one of £4 11*s.* 3*d.*, so that (taking into account the small number of trees on it) each tree on the mulched plot was worth three times (net) as much as each of those on the one which was treated with dried blood, potash and phosphate. It is obvious that such an increased value cannot continue to get larger for an indefinite period, but it certainly seems to be one worthy to be maintained; and there is the further important consideration that during its attainment, the fruit-bearing capacity of the trees has been brought to a high value in the shortest possible time.

As an extension of the trials, two new experiments on four plots were commenced in July 1907. The purpose of the first of these is to compare the yield from mulching with that from the application of cotton seed meal; that of the second is to investigate the effect of mulching on a steep slope. Neither of these is sufficiently advanced, as yet, to give definite information.

The value of the mulch method for the treatment of soil in orchards is thus indicated by means of the increased yields that have been obtained. An actual comparison of the growth of the trees, and of the state of the soil on the different plots only serves to uphold the conclusion that has already been reached. This fact will be best brought out by a quotation from the Dominica Botanic Station Report, 1907-8: ‘When the general health and growth of the trees on the plots are taken into account, it is at once seen that the individual trees on the mulched plots are much finer and better developed than those on the other plots. The soil also is better than that of any other plot: it is moist, friable and full of humus, and in a better condition generally, which appears calculated to ensure good crops for some time to come. It is also significant that the mulched plot is well covered by trees planted at the rate of 108 per acre, while the plot receiving no manure requires 178 trees per acre, or nearly 70 per cent. more.’ This healthy growth of the trees is not important from the point of view of fruit production alone. The power of resisting the attacks of pests of all kinds that it gives them is of the greatest value, especially in the case of a crop like cacao, which is susceptible to such attacks, and is so easily damaged by them.

Reference to the articles in the *West Indian Bulletin* that have been cited already, and to the Dominica Botanic Station reports will show that there has been no attempt to discourage the use of manures for cacao: on the contrary, their employment has been advocated, and the results are given of experiments which were designed for the purpose of investigating their effects. These, however, have not been considered in the present article, as its purpose has been to indicate the beneficial results which have been obtained from a method of treatment of the soil for cacao orchards, and to suggest the advisability of its adoption in plantations where other crops are raised in a similar manner.

THE SCARABEE OF THE SWEET POTATO.

BY H. A. BALLOU, M.Sc.,

Entomologist on the Staff of the Imperial Department of Agriculture.*

In the Lesser Antilles, sweet potatos are very often attacked by a small insect which is known in Barbados as Scarabee, and in the Leeward Islands as Jacobs. For several years past this pest has been very troublesome in potato fields in Barbados, and the loss to the planters and small cultivators has been very large. It is impossible to estimate this loss in terms of a money value, or as pounds of potatos, but certain estates have lost as much as one-third of their entire crop, and it may not be far from the true condition of affairs if the loss from this cause for the last four or five years should be estimated at this rate for the whole island.

On estates in Barbados, potatos are generally grown as one of the crops in the estate's plan of rotation; they are also grown by peasants in their small holdings and garden patches. On this account, and because a very large proportion of the crop is used locally as a part of the food supply of the population, it would probably be impossible to obtain even an approximate estimate of the area of the land devoted to the cultivation of sweet potatos, and the value of the crop.

The scarabee is not new in Barbados. The insect was described by an English entomologist as long ago as 1840. It is such a small insect and so rarely seen, except when numerous enough to attract attention by the damage it does,

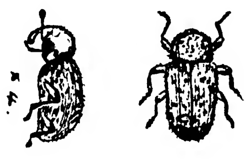

FIG. 10.
(*Cryptorynchus Batatae.*)

FIG. 11. Larva of the scarabee.

FIG. 12. Pupa (chrysalis) of scarabee.

*The thanks of the writer are due to Messrs. C. C. Gowdey, B.Sc., and C. W. Jemmett for assistance in inaugurating the field experiments with scarabee. These gentlemen were both temporarily attached to the staff of the Imperial Department of Agriculture at the time these experiments were started.

that it seems likely that it must have been abundant about 1848. It would be during a time when the scarabee was very abundant that specimens would be sent to England for identification.

From that time to this no remedies seem to have been devised for checking this pest. The planters at the present time are as uncertain as to how the attack begins, where the insect lives during the interval between crops, and what to do to prevent its ravages in sweet potato fields, as they could possibly have been in the years gone by.

This is probably due to two things: one is that the severe attacks of scarabee have occurred at intervals, a few very bad years on any estate or in any locality alternating with a period

FIG 13. Section through a sweet potato, showing effect of scarabee attack.

of good years, when the attacks were much less severe. As already stated, the system of growing sweet potatos in a rotation with sugar-cane and other crops has had a considerable influence in this matter. It is not likely that any system of treatment to reduce the numbers of the pest has ever had much influence in this direction. Sweet potatos seem to suffer more in dry weather than in wet, and it is likely that the periods of abundance of this pest have been dependent almost entirely on the conditions of the weather which have been experienced on any estate, or in any locality.

The crop years 1904-5 to 1908-9 have been dry years; that is to say, the rainfall during these four seasons has been considerably less than the average. It might be added that certain sections of the island have suffered very severely in consequence of the extreme drought that has been experienced. The severity of the attacks of scarabee has seemed, on the whole, to increase in direct proportion to the severity of the drought. In consequence of this, the attacks of the scarabee were so severe during 1908 that the attention of the Agricultural Society was directed toward this problem, and a meeting was devoted to a discussion of the subject, and of the experiments which might be carried out with a view to discovering some practical remedy. At the discussion by the Agricultural Society the writer of this paper suggested lines along which experiments might be tried, and several planters expressed willingness to co-operate and give the necessary assistance for carrying them out.

During the discussion several opinions were expressed by planters who were present. Nearly all those who spoke agreed on one point—that dry weather was the most powerful factor in the serious increase in numbers of the scarabee. They believed that with the advent of favourable growing seasons the attacks of scarabee would become so slight as to be comparatively insignificant. Another opinion which was expressed at this meeting was to the effect that something might be done to reduce the numbers of the scarabee by planting slips from a nursery, or from fields in which little or no scarabee attacks had been noticed during the season.

As a result of the interest which was manifested, field experiments were started in six different places in the island, and laboratory experiments which had been started earlier in the season were continued. In the laboratory, trials were made with vaporite, corrosive sublimate, and arsenic.

LABORATORY EXPERIMENTS.

Vaporite.—The several trials with vaporite indicated that if the insects could be confined in an atmosphere well saturated with the fumes of vaporite, they would be killed. This was shown by enclosing a number of beetles in a glass jar for different lengths of time, from a few minutes to twenty-four hours with varying amounts of vaporite. In another trial a number of scarabee weevils were enclosed in a bamboo joint the ends of which were covered with wire gauze. This bamboo containing the weevils, and a piece of potato infested with weevil grubs were buried 2 inches deep in a box of mould. The mould in this box had received an application of vaporite at the rate of 3 cwt. per acre. A similar joint of bamboo, containing weevils in the same way, was buried in mould in which there was no vaporite. Some weeks later they were both examined and no difference could be seen which might be due to the effects of vaporite. Several other similar trials indicate that these insects are very resistant to the effects of vaporite.

Corrosive sublimate.—Trials were made with corrosive sublimate to see whether pieces of potato treated with this poison would be eaten by weevils and the weevils killed by it. It was found that the weevils fed more freely on pieces of potato that were not poisoned, less on potato treated with a solution of 1 in 1,000, and least of all on potato treated with a solution of 1 in 500. At the end of sixteen days two-thirds of the weevils were dead in each of the experiments with corrosive sublimate, or ten out of fifteen in each case, while in the trial with potato not poisoned, which was used as a check, only two out of fifteen were dead.

Arsenic.—Trials were made with arsenic mixed with crushed sweet potato, both raw and boiled, and with cornmeal sweetened with molasses. It was found that the mixture of raw potato and arsenic was readily eaten and the beetles were quickly killed by it when used at a strength of 1 in 25. They were not so quickly killed by the same bait when the poison was used at the rate of 1 in 50. The bait made of cornmeal

was not found to be so effective as the raw potato, and the same might be said of the bait of boiled potato.

It was found in other laboratory trials that the scarabee weevils almost immediately seek out some hiding place. This tendency to hide from the light was also seen in the field. In a field where the potatos have just been dug, examination will show weevils hiding on the underside of bits of roots and vines, etc.

It was hoped to make some practical use of this habit in the field ; and in the various experiments tried, plots were laid out on which the treatment was to be traps of cane-trash, etc. It was intended that these traps should be visited from time to time and any weevils found hiding there should be killed. This was not done, and the experiments with these traps were consequently of no value.

One of the most effective remedies in dealing with scarabee is the complete burying of all infested material when the crops are dug. This is not always easy to do, especially in Barbados where the soil is not deep : but it is likely that if the potatos can be buried with a good covering of lime and 2 feet of mould, the weevils will all be killed.

In Antigua and in Nevis, the sweet potato weevil, which is known as Jacobs in those islands, is also a serious pest at times. Many field trials and a few careful experiments by planters have failed to give any definite measure of control. Vaporite is one of the substances which has been tried and it has given no better results than in the trial in Barbados.

In Nevis it is found that Jacobs is likely to be more abundant in dry seasons than in wet, and in dry loose soils than in heavy.

Soils in which there is a large amount of coarse trash and undecayed vegetable matter are always liable to more severe attacks than other more compact ones.

FIELD EXPERIMENTS.

WATERFORD. NO. 1.

Experiments were carried out at Waterford estate, on lands rented by the Botanic Station. The following notes, which have been furnished by Mr. J. R. Bovell, I.S.O., F.L.S., F.C.S., give an account of the experiments and the results. The following experiments were carried out on a field of $\frac{1}{4}$ acre which had been planted to thirty-two varieties of sweet potatos on July 13, 1908, as an experiment with varieties. On August 10, it was divided into eight plots for scarabee experiments. Each plot contained 108 sweet potato plants of four varieties. Two plots were treated with vaporite, one with air-slaked lime, one with carbon bisulphide, and four were untreated, or control plots.

The vaporite was worked into the soil as deep as possible. In No. 1, it was worked into the base of the hill, and in

No. 2 into the space between the hills. It was hoped to give the fumes every opportunity to penetrate through the soil.

Table I, part 1 shows the treatment each plot received, the yield of potatos, and the amount and per cent. of infested potatos in each case. It will be seen that the treatment had no effect on the percentage of infested potatos. Part 2 shows the results obtained with each variety.

TABLE I. PART 1.

Treatment.	Yield of potatos, in pounds.	Infested potatos, in pounds.	Infested potatos, per cent.
Vaporite (No. 1) at the rate of 4½ cwt. per acre	151	114	76
Control	329	211	61
Vaporite (No. 2) at the rate of 4½ cwt. per acre	126	89 5	71
Control	132	101	77
Air-slaked lime at the rate of 7½ cwt. per acre	245	160	65
Control	165	106	64
Carbon bisulphide at the rate of 17 gallons per acre	184	119	65
Control	176	107·5	61

These experiments had been carried out on plots which were laid out for quite a different experiment, and so it was thought desirable to repeat them on the same land, using only one variety, and thus doing away with the possibility of misleading results due to any immunity from, or susceptibility to, attack which one variety might possess in a greater degree than another.

TABLE I. PART 2.

Treatment.	Variety.	Yield of potatos, in pounds.	Infested potatos, in pounds.	Infested potatos, per cent.
Vaporite No. 1.	Thegania White	26	18	69
	Carolina Extra Early	28	24	86
	Poona Local	66	50	76
	Kapo	31	22	71
Control.	India Red	121	93	77
	Southern Queen (Weak type)	37	23	62
	Vineless Bunch	32	25	78
	Southern Queen (Strong type)	139	70	50
Vaporite No. 2.	Caroline Lee	57	42	74
	Georgia	16	11·5	72
	Alabama	13	6	46
	Ihumai	40	30	75
Control.	Yellow Red	33	26	79
	Shanghai	17	16	94
	Pumpkin	47	33	70
	Van Nest Red	35	26	74
Lime.	Dhamakia White	11	5	45
	Red Nansemond	88	55	63
	Japan Brown	98	60	61
	Norton	48	40	83
Control.	Barbados Caroline Lee	55	42	76
	Johns	55	36	65
	John Burnett	21	6	29
	Pikonui	34	22	65
Carbon bisulphide.	Early General Grant	41	33	80
	Kamelo	88	64	73
	Florida	10	5	50
	White Gilk (6 months)	45	17	38
Control.	Kala	61	27	44
	Yellow Stausberg	44	32	73
	Ticotea	42	30	71
	Hailonaipu	29	18·5	64

WATERFORD, NO. 2.

A second series of experiments was started with only the one variety, Water-hole Monday. There were seven plots, in each of which there were ninety potato plants. Four of these were treated and three were untreated, or control plots.

Table II shows the treatment given and the results obtained in terms of total yield compared with the amount of infestation and the per cent. of infestation.

TABLE. II.

PLOT REAPED.

Treatment.	Yield of potatos, in pounds.	Infested potatos, in pounds.	Infested potatos, per cent.
Vaporite at the rate of 3 cwt. per acre ...	249	185	74
Control	147	123	84
Air-slaked lime at the rate of ½ ton per acre	189	168	89
Control	133	117	88
Carbon bisulphide at the rate of 17 gallons per acre	154	141	92
Control	125	105	84
Removal of all infested material and roots before planting ...	140	116	83

The amount of vaporite applied and the amount of lime was less than in the preceding series, but the amount of carbon bisulphide was the same. The vaporite and the lime were sown broadcast and mixed thoroughly with the soil when the hills were made. The carbon bisulphide was applied to every other hill. A hole about an inch in diameter and 5 or 6 inches deep, was made with a stick, and the liquid poured in. The hole was immediately plugged with earth, which was trodden in.

In the treatment of the fourth plot, an attempt was made after the previous experiment, to remove from the land all potatos and bits of roots which were attacked, or which might harbour scarabee beetles. The insecticides were applied on January 5, and the potato cuttings planted on January 14, and the plot was reaped on May 25 and 26, 1909.

These figures show that no beneficial results were obtained from the treatment given or the insecticides applied in any case, and confirm the results of the first series. It may be mentioned that in digging the potatos some of them were found badly infested with scarabee, in soil impregnated with vaporite and smelling strongly of this material. Others were found also badly infested in soil in which the lime could be plainly seen.

SUMMERVALE.

The experiments at Summervale comprised 2½ acres, which formed a portion of a field of 3 acres in which potatos had been grown the previous season. They were planted on November 10, 1908, and reaped on May 12 to 19, 1909. There were twelve plots arranged as shown in Table III, each of which contained nearly ¼ acre. The results are given in pounds of sound and infested potatos, and in per cent. of infested potatos, sound potatos including those that are saleable under ordinary conditions, and infested, those that are unsaleable.

It will be seen that five of the twelve plots were marked 'check', which indicates that they had no treatment other than that ordinarily given sweet potatos in Barbados. Plot V might be included also, as it really had no treatment. It was merely a plot near the centre of the field in which three varieties were planted. Plot VII included two varieties.

The analysis of the field and the results obtained are given herewith.

Plot 1. Soil black, surface level.

Treatment. Traps of cane trash. When the experiment was planned it was intended that these traps should be visited and notes made as to the abundance of the weevils in them, and the weevils destroyed. This was not done, and the traps merely furnished hiding places for the adult weevils.

Results. Sound potatos 891 ℔., infested 1,102 ℔., or 56 per cent.

Plot 2. Check. Soil and surface as in Plot 1.

Results. Sound potatos 786 ℔., infested 1,062 ℔., or 56 per cent.

Plot 3. Soil brown and light, surface sloping, well drained.

Treatment. Vaporite at the rate of 3 cwt. per acre, worked into the base of the hill soon after planting. It was planned to have this application made before the plants were put in, but the supply of vaporite did not arrive in time.

Results. Sound potatos 383 ℔., infested 558 ℔., or 59 per cent.

Plot 4. Check. Soil and surface as in Plot 2.

Results. Sound potatos 463 lb., infested 215 lb., or 32 per cent.

Plot 5.

Treatment. None. Variety trial.

Results.

Minuet	sound potatos	313 lb.,	infested 184 lb.	or 37 per cent.
Caroline Lee	" "	275 "	" 155 "	" 36 " "
White Sealy	" "	353 "	" 65 "	" 16 " "
	Total	946	404	30 per cent.

Plot 6. Check. Soil and surface as in Plot 1.

Results. Sound 1,206 lb., infested 503 lb., or 30 per cent.

Plot 7. Soil and surface as in Plot 1.

Treatment. Seed (pieces of potato planted) was treated with corrosive sublimate 1 part in 500 parts of water.

One-third was White Sealy, and two-thirds Trinidad Red.

Results.

Sound potatos 303 lb., infested 116 lb., or 28 per cent.
" " 517 " " 318 " " 35 " "

Plot 8. Check. Soil black and thin on top of brow.

Results. Sound potatos 1,031 lb., infested 202 lb., or 20 per cent.

Plot 9. Soil as in Plot 2. Thin and browy, well drained.

Treatment. Lime at the rate of ½ ton per acre worked into the hills.

Results. Sound potatos 649 lb., infested 62 lb., or 9 per cent.

Plot 10. Soil black, undulating, thin in one part.

Treatment. Vaporite at the rate of 3 cwt. per acre, worked into the hills when the plants were two months old.

Results. Sound potatos 1,276 lb, infested 313 lb., or 20 per cent.

Plot 11. Soil as in Plot 5.

Treatment. All pieces of roots as far as possible were carefully cleared, after digging the previous crop, and after each of two subsequent forkings.

Results. Sound potatos 842 lb., infested 269 lb., or 24 per cent.

Plot 12. Check. Soil as in Plot 5.

Results. Sound 678 lb., infested 119 lb., or 15 per cent.

Mr. Skeete furnishes the following note : 'Plots 1, 2 check, and 6 check were most infested. The trouble seemed to commence at that corner of the field, and the land being flatter retained more moisture and potatos developed more. Most of the other plots are undulating and well drained, and owing to the drought, developed later, giving smaller yield.'

TABLE III.

I.	II.	III.
Traps of cane trash, etc.	Check.	Vaporite 3 cwt. per acre.
Sound .. 891	Sound .. 786	Sound ... 383
Infested ... 1,102	Infested ... 1,062	Infested ... 558
Total 1,993	Total 1,848	Total 941
56 per cent. infested.	56 per cent. infested.	59 per cent. infested.
VI.	**V.**	**IV.**
Check.	Varieties.	Check.
Sound .. 1,206	Sound ... 941	Sound ... 463
Infested ... 503	Infested ... 404	Infested ... 215
Total 1,709	Total 1,345	Total 678
30 per cent. infested.	30 per cent. infested.	32 per cent. infested.
VII.	**VIII.**	**IX.**
Corrosive sublimate.	Check.	Lime ½ ton per acre.
Sound ... 820	Sound ... 1,031	Sound ... 649
Infested ... 434	Infested 262	Infested ... 62
Total 1,254	Total 1,293	Total 711
35 per cent. infested.	20 per cent. infested.	9 per cent. infested.
X.	**XI.**	**XII.**
Vaporite.	Cleaning up pieces of roots, etc.	Check.
Sound ... 1,276	Sound ... 842	Sound ... 678
Infested ... 313	Infested ... 269	Infested ... 119
Total 1,589	Total 1,111	Total 797
20 per cent. infested.	24 per cent. infested.	15 per cent. infested.

OTHER EXPERIMENTS.

At Bulkeley experiments were carried out on a field of 2 acres divided equally by the railroad. There were four plots on each side of the railroad. Of the eight plots, four were checks, one was treated with vaporite at the rate of 3 cwt. per acre, one with lime at the rate of ½ ton per acre, one with a poison bait of cornmeal (25 lb.) and arsenic (1 lb); and one with a poison bait of crushed potato (25 lb.) and arsenic (1 lb).

This field was planted with the Trinidad Red on October 29, 1908, and reaped about the end of May 1909.

There were only two or three holes where the potatos showed any infestation at all, and the whole crop was saleable. There was no difference in yield between the treated and untreated plots. The slips used for planting were from a nursery which had been stocked with pickings of small roots after reaping the crop early in the previous season.

Series of plots were also laid out at Drax Hall, Waterford, and Searles on the same lines as those at Bulkeley, but at Drax Hall none of the potatos were attacked either in the experimental portion of the field or in the remainder; and at Searles and Waterford there was no record made of the infestation. The crop was sold off at the first appearance of scarabee, the experimental plots included.

Table I shows that there is very little difference in varieties since each of the eight plots contained four varieties, and the infestation by the plot ranged between 61 and 77 per cent. Part 2 of this table shows that varieties varied from 29 per cent. in the case of John Burnett to 94 with Shanghai. These were both control plots in which the infestation was 64 and 77 respectively. It does not seem that the treatment given had any influence on the results.

The results given in Table II should show more effect of treatment since this experiment was all of one variety and planted for the purposes of this experiment. The difference in percentage of infested potatos is so small, and the total infestation is so very high that this experiment must be taken as giving no practical results. The vaporite plot gave the smallest percentage and the largest yield. This cannot be taken as showing very much, because it was found that in hills of potatos where every potato was absolutely spoiled by the scarabee, the vaporite could be seen in the ground and its characteristic odour was very perceptible in the surrounding soil.

The results given in Table III are of interest in showing the relative yield and infestation according to the quality of the soil.

The left-hand column of the table represents that part of the field in which the soil was of best quality, and in which also the largest degree of moisture was present during the growing season.

The right-hand column represents that part of the field where the soil was thin and dry. The middle column is, of

course, intermediate. There is a tendency for the percentage of infestation to follow the yield; that is to say, the highest percentages are generally shown in the plots with the highest yield. It will be seen also, that the highest percentage is shown by the portion of the field represented by the top of the table in plots 1, 2, and 3. The vaporite plots, Nos. 3 and 10, are at opposite corners of the field and do not show any beneficial results from the treatment received; in fact, plot 3 shows the highest percentage infested of all, while plot 10 shows the same percentage as plot 8 which adjoins it. The smallest percentage of infestation is shown in plot 9, which gave a yield of 711 lb., of which only 9 per cent. were infested. This was also the smallest yield of any plot with the exception of plot 4.

The results shown by this table lead to the belief that none of the remedies had any effect on the scarabee or on the yield, and further, that during 1908-9 the conditions which were most favourable for the growth of the potatos were also most favourable for the scarabee. In this experiment it is shown that heavy soil is not less favourable to the scarabee than light, dry soil.

The results of this season's experiments then, may be summarized thus: The analysis of three experiments is given above in which none of the remedies tried gave any definite results; two experiments were carried out in fields where there was no infestation, and three in fields in which the scarabee appeared, and from which the potatos were dug for sale without waiting for the conclusion of the experiment, and no notes were made as to the conditions of the different plots. It is possible still to make only general recommendations. The rotation of crops in such a way that sugar-cane is always grown between crops of potatos is strongly recommended.

Thorough cleaning of the land after harvesting the crops, of all infested material, and of all roots, vines, etc., ought to be carefully carried out. All infested material should be buried with lime. Planting the field from slips from the nursery seems likely to give good results. The 'pickings' or bits of roots from uninfested or slightly infested fields may be used to establish a nursery from which slips can be taken. If these nurseries are established at some distance from potato fields, and if they are not kept long enough for any potatos to ripen, they will not become infested.

The potatos should be harvested as soon as they are ripe. It it likely that this last recommendation suggests more definite measures of control than any other and it may to a large extent explain why the loss from scarabee is so much worse in dry seasons than in wet. The practice of storing potatos in the ground awaiting the right conditions of market seems to be fixed as a part of the local agriculture. Potatos are sold in the field and the estate manager has none of the responsibility of harvesting or storing the crop. The need of keeping potatos over in the ground seems to be greater in dry than in wet seasons; there is smaller opportunity for planting, and as the potatos ripen more quickly, it comes about that a crop is often kept in the ground for two or three months after it is ready for harvesting.

The sweet potato weevil was described by Mr. C. O. Waterhouse. The original description given below is copied from *Proceedings of the Entomological Society of London*, June 4, 1849.

Cryptorynchus Batatae.

'Cr. oblongo-ovatus, nigro-piceus; squamosus, supra spinulus erectus nigris et pallidis obsitus; *rostro* brevi, crasso, arcuato, ruguloso-punctato, carinato; *thorace* ruguso-punctato, setis (plerumque nigris) obsito, postice squamulis flavidis marginato, doiso linea, punctisque parvulis, albis, notato; *elytris* ocellato-punctato striatis, interstitiis fere planis, fusco, nigro, alboque variegatis, plaga communi, transversa, sordide alba, subapicali, ornitis; *femoribus* indistincte dentatis; *scutello* minutissimo.

Long. corp. 2 lin. Hab. Barbados.

'This is a minute species of *Cryptorynchus*, and differs somewhat from the type of the genus—if we regard the *Cr. Lapathi* as such—though not sufficiently, as it appears to me, to require removal from that section. Its form is more elongated, and its scutellum is so minute as to require the aid of a strong lens to detect it; the insect nevertheless has well developed wings: the rostrum is stouter, and subdepressed, and is inserted in a very deep rostral groove, which terminates between the coxae of the anterior pair of legs; the scape of the antennae is shorter and stouter, the basal joint of the funiculus is also stouter, the second joint is of an elongate obconic form, the remaining joints are also obconic, but very short; the club is tolerably developed, and of a short ovate form; the femora are rather less stout, and very indistinctly toothed beneath.

'The head is covered chiefly with pale scales, but has two black spots; the thorax is rather broader than long, rather suddenly contracted in width from the middle to the fore part, and with the lateral margins of the hinder half nearly parallel, being very slightly rounded; the upper surface is densely beset with short, stiff, erect bristles, which are most of them black, but some few are white, and are aggregated in parts so as to form small spots and a white mesial line; the hinder margin is clothed with orange-yellow scales, and these form a small spot near the scutellum. The elytra are more than three times the length of the thorax, and about half as wide again, the humeral angle is rounded, the sides nearly parallel, except towards the apex, where they are rather suddenly contracted, and obtusely rounded: they are covered with scales, some of which are dirty white, others brown, and others black, producing a variegated appearance; in each of the tolerably large punctures of the striae is a white scale: on the fourth interstice from the suture is a small white spot, which is rather more conspicuous than (page lxx) others; it is situated above the middle of the elytron, and at a short distance from the apex of the elytra is a conspicuous transverse dirty white patch, in which is a waved black line. Besides the scales there are scattered dark and pale hairs on the elytra. On the under parts of the insect are scattered pale scales. The limbs are clothed with setiform scales, most of which are pale'.

Other Pests of Sweet Potato.

In addition to the scarabee or Jacobs there are several other pests of sweet potatos some of which are capable of inflicting very great injury on the crop. The scarabee attacks the roots and the base of the vines where they are thickened and woody in structure. The leaves are attacked by the caterpillars of the potato moth, by red spider, thrips, and flea beetles, while plant lice, mealy bug, white fly, and scale insects are also sometimes found on leaves and vines. The larvae of the root borer of the sugar-cane and of the hard back also sometimes attack sweet potato roots.

THE SWEET POTATO MOTH.

(*Protoparce cingulata*, Fabr.)

This insect is perhaps the most abundant of all the hawk moths in Barbados, and it is abundant also in the other West Indian islands. It is known locally as the 'Harry Booby' or 'bat'. It has an expanse of wings of 4 inches and a length of body of 1¾ inches. The potato moth can be distinguished by the pink or reddish spots, five on each side of the body, and the reddish markings on the hind wings.

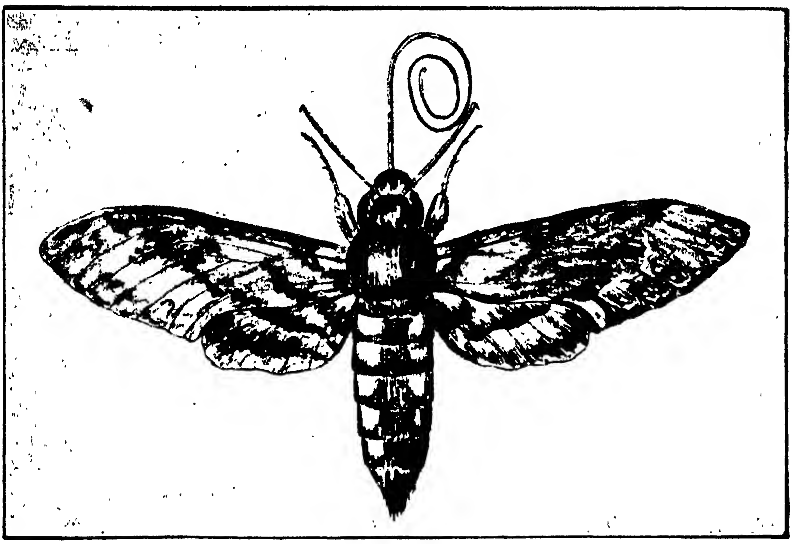

Fig. 14. The sweet potato moth. (*Protoparce cingulata*, Fabr.)

The preferred food seems to be the sweet potato, and a severe attack often results in the complete loss of the foliage over entire fields, only bare, stripped vines being left.

Sometimes the attack begins at one side of the field and the caterpillars travel across in solid ranks, feeding as they go and leaving behind them only bare vines.

The female moth deposits the eggs on the leaves of the potato, and the caterpillars from them begin feeding as soon as they are hatched. These caterpillars are voracious feeders,

each one eating a tremendous amount of food in proportion to its size, during its entire life which lasts about three weeks.

When the larval or caterpillar stage is finished, that is when the caterpillars are full-grown, they burrow into the ground and form the peculiar pupa or chrysalis (see fig. 16). This pupal condition lasts for about ten or twelve days and then the moths appear. After mating, the females deposit

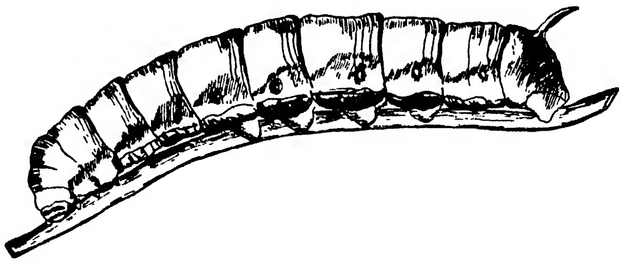

FIG. 15. Larva of the sweet potato moth.

their eggs from which another brood of caterpillars hatch. These severe attacks over large areas occur only at intervals of several years. This is probably due in large measure at least to the abundance of their natural enemies, more especially to a small fly which is parasitic on the larvae and pupae of this insect. This fly (*Sturmia distincta*) is shown at fig. 17.

At the close of a severe attack of the potato worm enormous numbers of the pupae may be found in the ground within 2 or 3 inches of the surface. If a good number of these are carefully taken out and kept in glass jars covered with fine muslin, for a few days, it may easily be seen how great is this parasitism. Probably only a few moths will be obtained and many flies. This parasitism is generally greatest at the end of very severe attacks, which explains why the potato moth is so comparatively scarce immediately after these attacks.

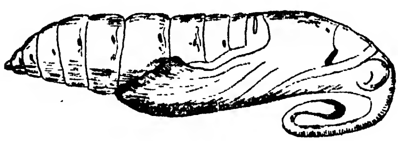

FIG. 16. Pupa of the sweet potato moth.

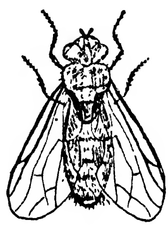

FIG. 17. *Sturmia distincta.*

The attacks of the potato worm may be controlled by means of Paris green used in the same way as on cotton for the control of the cotton worm, i.e., applied as a dust, from a cloth bag, in a mixture with lime at the rate of 1 of Paris green to 6 of lime. As these attacks usually begin in spots scattered over the field, or in the form of an invasion from one

side of the field, it will generally not be necessary to apply Paris green to the entire field, but only to the attacked spots or to a strip across, in front of the line of march of the invasion. If the entire field had to be dusted, it is probable that ¾ lb. of Paris green or 5¼ lb. of the mixture would be sufficient for an acre.

RED SPIDER.

Red spider is known as a pest in many parts of the world, and is familiar to most persons who have had experience with field crops or ornamental plants. Red spider is not an insect, but a small mite related to the true spiders.

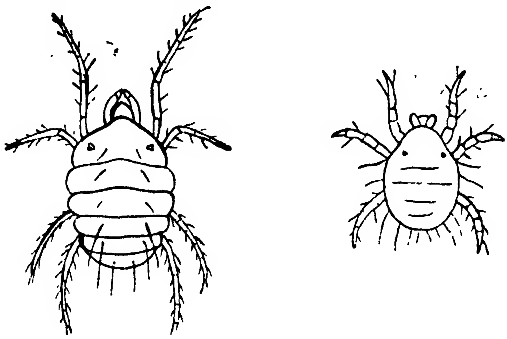

FIG. 18. The Red Spider (*Tetranychus telarius.*)

The red spider of the sweet potato (*Tetranychus telarius*) lives on the under side of the leaves of the potato, protecting itself by means of a delicate web, which it spins and under which it lives. The red spider may easily be seen with the naked eye, on account of its bright reddish colour, but it is much too small for any details of its appearance to be made out, without the aid of a magnifying glass. The attacks of the red spider cause the leaves of the potato to turn yellow and dry up.

As these attacks usually occur in small spots or patches scattered over the field, they can often be seen and treated before they become general.

Sulphur, used in a mixture with lime and applied dry, has been found a good remedy. It may be applied by means of the cloth bags, the Acme powder bellows, or the Champion powder gun. The strength of the mixture may vary from equal parts of lime and sulphur, to 1 of sulphur to 4 of lime.

It is likely that it would be found satisfactory to use the sulphur mixed with water, and apply as a spray. For this purpose, 1 lb. of sulphur to 25 gallons of water would be used. The sulphur must be carefully mixed with the water so that there will be no lumps. Whale-oil soap or kerosene would also be found satisfactory. In applying insecticides for the control of the red spider, care should be taken to reach the under side of the leaves as much as possible.

Thrips and flea-beetle rarely occur in sufficiently large numbers to cause them to be regarded as pests. Thrips would

be controlled by the same means as the red spider, while severe attacks of the flea-beetle might be controlled by the use of Bordeaux mixture and Paris green applied as a spray, with Paris green used at the rate of 1lb. to 150 gallons of Bordeaux.

Planters do not generally consider the sweet potato crop of sufficient value to warrant the application of costly remedial measures. It is argued in the case of the pests which attack the leaves, that the potato will put out a new covering of foliage, after the attack of the pests or red spider, and that the crop is only set back for a time. The remedies are not expensive of application however, and it is likely that they will always be more than repaid in the increased crop.

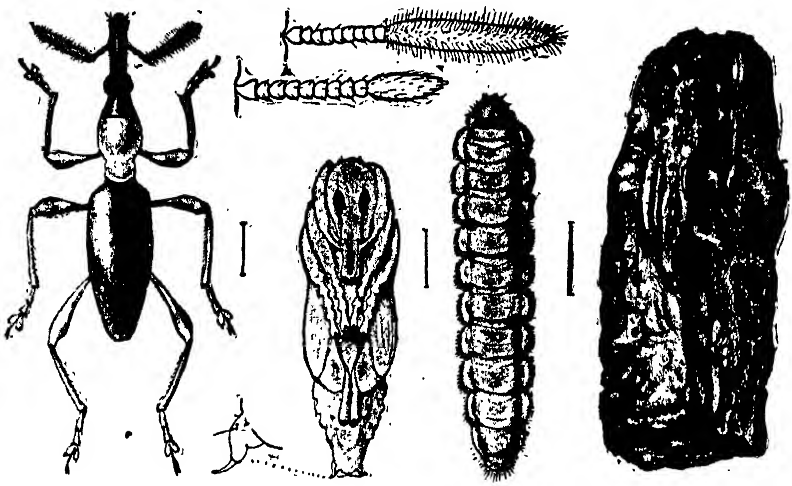

FIG. 19. The sweet potato weevil. (*Cylas formicarius*). From United States Department of Agriculture.

The sweet potato weevil of Jamaica and the Southern United States is *Cylas formicarius*, and it will be seen on reference to the illustrations (figs. 10, 11, and 12, and fig. 18), that it is quite distinct from the scarabee, being much larger and of a very different form.

Pages 107-196 issued September 25, 1909.

LEGISLATION IN THE WEST INDIES FOR THE CONTROL OF PESTS AND DISEASES OF IMPORTED PLANTS.

BY H. A. BALLOU, M.Sc., ENTOMOLOGIST ON THE STAFF OF THE IMPERIAL DEPARTMENT OF AGRICULTURE.

Previous to the establishment of the Imperial Department of Agriculture, several colonies had enacted legislation by means of which it was possible to prohibit the importation of any or all plants from a specified country, or countries, in which any special disease was known to exist, such as, for instance, from Ceylon, owing to coffee leaf disease.

The earliest of these laws seems to have been the Jamaica Seeds and Plants Importation Law, No. 4 of 1884 which, amended by No. 25 of 1891, is still in force. Proclamations which have been issued under these two laws provide for the fumigation of all plants imported into Jamaica at the present time.

In 1890, the Government of Trinidad passed a law, No. 8 of 1890, which prohibited the importation of diseased sugar-canes, and in 1894 another, No. 28 of 1894, which similarly provided for the prohibition of the importation of plants, seeds and beans, affected, or suspected to be affected, with disease. In 1898, the Trinidad Agricultural Society put forward suggestions (Society Paper No. 107) for a system of inspection of imported plants, with powers for the destruction of any such plants found to be affected with disease. Laws similar to those in Jamaica and Trinidad were in force in the islands of the Windward and

Leeward groups, making it possible to prohibit the importation of plants. The following list gives the numbers of these laws :—

Jamaica	No. 4 of 1884.
	No. 25 of 1891.
Trinidad and Tobago	No. 8 of 1890.
	No. 28 of 1894.
Windward Islands :	
Grenada	No. 14 of 1891.
St. Vincent	No. 10 of 1895.
St. Lucia	No. 5 of 1895.
Leeward Islands :	
Antigua	No. 4 of 1897.
St. Kitts-Nevis	No. 2 of 1897.
Montserrat	No. 3 of 1897.
Virgin Islands	No. 3 of 1897.
Dominica	No. 3 of 1898.

It will be seen that, previous to the organization of the Imperial Department of Agriculture in 1898, all the colonies except British Guiana and Barbados had laws calculated to prevent the introduction of diseases and pests of plants by prohibiting the importation of plants from certain places, but none of those laws provided for inspection, fumigation or disinfection of plants on arrival at their destination.

More recently, laws have been passed in all the colonies making provision for the introduction of plants into any island under conditions which as far as possible reduce the risk of introducing pests and diseases. Many of these laws are given in the following pages, with comments, and comparisons with the provisions of those of different places. Certain of these have appeared previously in the *West Indian Bulletin*, and are included among the references in the list given below.

When the Imperial Department of Agriculture was organized in 1898, one of the first of the important problems which presented itself for consideration was the development of a system of control of insect pests and fungoid diseases. With this object in view, an Entomologist and a Mycologist were appointed on the staff of the Department. In this connexion also, the Secretary of State for the Colonies addressed a despatch, dated October 3, 1899, to the Officers administering the Government in these islands, in which it was suggested that uniform laws should be made in the West Indies, British Guiana, Bermuda, the Bahamas and British Honduras.

This despatch indicated the danger of diseases being spread by means of plants imported into one colony from another, referred to the laws that had previously been passed for the purpose of prohibiting the importation of certain seeds, plants, etc., from countries where special diseases were known to exist, and pointed out that no system had been adopted in any of the West Indian colonies to check and, if possible, prevent the importation of diseased specimens. It was further announced that an Economic Entomologist would be appointed on the staff of the Imperial Department of Agriculture. The despatch, in addition to this, suggested that a system of inspection might be devised, under which all imported plants should

be inspected by an Officer of the Government, and that plants which were admitted after inspection should be recorded, the address of their destination being kept. in order that they might be inspected from time to time.

During 1900 and 1901, the Imperial Commissioner of Agriculture issued three circulars for the information of those colonies which were desirous of taking steps for the better control of imported plants. The first of these contained the despatch of the Secretary of State for the Colonies dated October 3, 1899, together with a letter from the Government Secretary of British Guiana, Society Paper 107 of the Trinidad Agricultural Society, and suggestions for a Plant Disease Ordinance. (*West Indian Bulletin*, Vol. I, pp. 314 and 323.) The second of these contained an extract from the Report of the Directors of the Royal Botanic Gardens, Ceylon, 1889, in regard to experiments in the fumigation of seeds and plants with hydrocyanic acid gas; an extract from the Report of the Government Entomolgist, Cape of Good Hope, 1899, import regulations regarding fruit trees, etc., and a memorandum by the Entomologist on the staff of the Department, with regard to certain insects likely to be introduced with imports of plants, fruit, etc. (*West Indian Bulletin*, Vol. I, pp. 457-62.) The third circular gave useful information as to the results of experiments in fumigating plants, etc., with hydrocyanic acid gas. A further circular was issued in July 1904, containing the Jamaica laws, the titles of several other laws then in force in the West Indies and directions for fumigating plants with hydrocyanic acid gas.

Following on the suggestions of the Secretary of State for the Colonies in the despatch of October 3, 1899, the Imperial Commissioner of Agriculture issued a circular letter, under date of August 3. 1900, in which the fumigation of imported plants with hydrocyanic acid gas was suggested as a means of treating imported plants for the destruction of insect pests. Another circular was issued in January 1901, in which particulars as to plant importations, including fruit and vegetables, into the several colonies were asked for. The returns which were supplied in response to this request furnished a basis on which suggestions for the treatment of imported plants were made by the Officers of the Department. The subject of plant diseases and importation of plants came up for discussion at the first, second and fourth Agricultural Conferences. The papers and discussions were published in the *West Indian Bulletin*. The following list of references includes the papers and discussions mentioned, and other articles which have appeared in the *West Indian Bulletin* in connexion with the subject. :—

West Indian Bulletin, Vol. I, p. 133. The Prevention of the Introduction of Fungoid and Insect Pests in the West Indies, by Wm. Fawcett. (Conference of 1899.)

West Indian Bulletin, Vol. I, p. 309. Legislation suggested for the Treatment of Insect and other Pests Affecting Economic Plants. (Conference of 1900 : Discussion.) With appendix giving laws in force in Jamaica (1884 and 1891), Trinidad and Tobago (1890 and 1894), with Suggestions for a Plant Disease Ordinance.

West Indian Bulletin, Vol. I, p. 457. Fumigation of Seeds and Plants, with Import regulations of Cape of Good Hope, and Memorandum by Mr. H. Maxwell-Lefroy on pests likely to be introduced with plants.

West Indian Bulletin, Vol. II, p. 318. Suggestions for Insect Control in the West Indies, by H. Maxwell-Lefroy.

West Indian Bulletin, Vol. II, p. 344. Treatment of Imported Plants at Jamaica.

West Indian Bulletin, Vol. III, p. 140. Suggestions for controlling the Importation of Insect Pests by H. Maxwell-Lefroy.

The *Agricultural News* has contained two articles under Insect Notes (Vol. III, pp. 74 and 138) on this subject, in which the necessity for regulations to prevent the importation of insect pests has been brought out, and plans for fumigating chambers and directions for the fumigation of plants etc., have been given.

Some of the most destructive pests and diseases known in present-day agriculture are those which have been transported from their native localities to other regions. Many of these have in all probability been carried on, or with, their food-plant or host-plant and have become established before their presence was known. Insect pests are likely to be much more destructive when transported to new localities, because they are often not controlled, as in their native environment, by natural enemies. The subject of preventing the introduction of pests and diseases, in connexion with the importation of plants, has been considered in most of those countries in which the agricultural industries are of great importance.

The West Indian Islands and the British Colonies in the American tropics depend almost entirely on agriculture for their welfare, and it would seem essential that everything should be done that can be done to ensure protection from infestation.

The present paper gives an account of the progress of legislation for the purpose of controlling plant importations, with copies of some of the earliest laws enacted, and an account of those at present in force which have a bearing on this subject.

These laws are compared and discussed, and the prominent features of each are mentioned.

In the following pages, the legislation is taken by islands and by colonies, and the closing paragraph presents a comparison between the legislation of the several governments, in regard to the control of imported plants.

In a subsequent paper, shortly to be published, it is proposed to give an account of the various methods of disinfection and fumigation, with directions for carrying them out under different circumstances, as well as a further discussion of the general subject of importation of insect pests and fungoid diseases, especially with reference to the laws at present in force or liable to be enacted in these colonies.

JAMAICA.

The laws in force in Jamaica for the control of insect pests and fungoid diseases on imported plants were used as the foundation on which legislation for the same purposes has since been enacted in many Colonies and Presidencies.

The text of the Jamaica Law No. 4 of 1884 is reproduced herewith, together with that of No. 25 of 1891. It will be seen that these two laws are to be taken and read as one, and that sections 1 and 2 of the Law 25 of 1891 are intended to make the provisions of section 1 of the previous Law (4 of 1884) more general and more comprehensive.

JAMAICA—LAW 4 of 1884.

The Seeds and Plants Importation Law, 1884.

[*31st October, 1884.*]

Whereas it is expedient to take precautions against the introduction into this Island of leaf and other kindred diseases in plants, and with that view to empower the Governor by Proclamation to prohibit the importation of seeds, plants or soil, either altogether, or from such country or countries, or except on such conditions, as he may see fit;

Be it enacted by the Governor, with the advice and consent of the Legislative Council of the Island of Jamaica, as follows:—

Power to Governor by proclamation to prohibit or restrict the importation of seeds or plants &c.

1.—It shall be lawful for the Governor, from time to time, by Proclamation to be published in the Jamaica *Gazette*, to prohibit the importation of seeds, plants, or any description of earth or soil, or any article packed therewith, that may have come either directly or indirectly from any country that may be named in such Proclamation: and also in like manner to prescribe the conditions under which alone the importation of any of the articles aforesaid shall be permitted that may have come either directly or indirectly from any country named in such Proclamation, the importation from which is not absolutely prohibited; and any such Proclamation as aforesaid from time to time to revoke or vary.

Such prohibited articles to be deemed to be prohibited goods, and conditions to be deemed restrictions, under the Customs Laws.

2.—Any of the articles aforesaid coming as aforesaid from any country the importation from which is for the time being prohibited, and any of the articles aforesaid arriving as aforesaid from a country the importation from which is allowed upon conditions only, until and unless such conditions shall have been complied with to the satisfaction of the Principal Officer of Customs at the port of arrival, shall be deemed to be prohibited goods within the meaning of the Laws relating to Customs; and any such conditions aforesaid shall be deemed to be restrictions within the meaning aforesaid.

Onus probandi as to place from which articles are imported.

3.—So long as any Proclamation as aforesaid is in force, any of the articles aforesaid coming from parts beyond the sea may be deemed to have come from a place the importation from which is prohibited as aforesaid, and may be treated accordingly, unless the Importer satisfies the Principal Officer of Customs at the Port of arrival to the contrary.

JAMAICA—LAW 25 of 1891.

A Law in aid of the Seeds and Plants Importation Law 1884.

[*27th May 1891*]

Preamble.

Whereas it is apprehended that leaf and other kindred diseases in plants may be introduced into the Island otherwise than by means of seeds, plants, earth or soil, or articles packed therewith, introduced into the Island from a Country named in a Proclamation of the Governor issued under Law 4 of 1884, and it is expedient accordingly to pass a Law in aid of the said Law 4 of 1884;

Be it enacted by the Governor and Legislative Council of Jamaica, as follows:—

Power to prohibit the importation of any goods, packages coverings, &c.

1.—It shall be lawful for the Governor, in and by any Proclamation issued or to be issued under the Provisions of the said Law, to prohibit the importation from the Country named in such Proclamation of any particular goods, packages, coverings, or other articles or things, to be named in such Proclamation, which in his judgment are likely to be a means of introducing diseases in plants from the Country to which such Proclamation applies.

Prohibited packages, goods, &c., subject to Law 4 of 1884.

2.—Any goods, packages, coverings, articles or things, named under the Provisions of this Law in any such Proclamation shall be subject to all the Provisions of the said Law applicable to seeds, plants and other things, named in any such Proclamation under the Provisions of the said Law.

Law 4 of 1884 incorporated.

3.—This Law and Law 4 of 1884 shall be read and taken together as one Law.

JAMAICA.

GOVERNMENT NOTICES.

Colonial Secretary's Office.

No. 78.—2.

10th September, 1901.

It is hereby notified, for general information, that the Jamaica Agricultural Society having called the Governor's attention to the need for protecting this colony against the importation of diseased plants, His Excellency, on the recommendation of the Board of Agriculture, has deemed it advisable to issue the following proclamation, prohibiting the importation from the countries named, except at the Port of Kingston, of plants, etc., and their coverings, and providing for their being fumigated immediately on importation.

By Command,

SYDNEY OLIVIER,

Acting Colonial Secretary.

[L.S.]

A. W. L. HEMMING.

By His Excellency, SIR AUGUSTUS WILLIAM LAWSON HEMMING, Knight Grand Cross of the Most Distinguished Order of St. Michael and St. George, Captain-General and Governor-in-Chief in and over the Island of Jamaica and its Dependencies.

A PROCLAMATION.

By virtue of the power in me vested in that behalf by the first Section of Law 4 of 1884, 'The Seeds and Plants Importation Law, 1884,' and by the first and second sections of Law 25 of 1891, 'A Law in aid of the Seeds and Plants Importation Law, 1884;'

I do hereby prohibit, until further Proclamation, the importation into this Island, at any port except Kingston, of any plants, cuttings, buds or grafts or any goods, packages, articles, coverings or things in which the said plants, cuttings, buds or grafts may be packed or otherwise contained from any of the Countries hereinafter named, viz :—

The British Islands, Sweden, Norway, Denmark, Germany, Austria, Holland, Belgium, France, Spain, Portugal, Italy, Russia, Greece, Bulgaria, Servia, Roumania, Montenegro, Turkey, China, Japan, India and Burmah, Ceylon, Straits Settlements and Malay Peninsula, Sumatra, Java, Borneo, Philippine Islands, Persia, Arabia, Africa (any part), Madagascar, Mauritius, Réunion, Canada, United States, West Indies, Mexico, British Honduras, Honduras, Guatemala, Nicaragua, San Salvador, Costa Rica, Columbia, Venezuela, Guiana, Ecuador, Peru, Brazil, Paraguay, Uruguay, Argentine Republic, Chili, Bolivia, Fiji, Sandwich Islands, and other Polynesian Islands, Australia (any part), Tasmania and New Zealand.

And I do hereby accordingly revoke the Proclamation issued by Sir Henry Arthur Blake and dated the sixth day of September, 1895, under which orange plants, cuttings buds, or grafts might be imported at other ports besides Kingston.

And I do hereby under the sections of Law quoted above further proclaim that immediately on the importation into this Island of any plants, cuttings, buds or grafts, or of any goods packages, coverings or things in which such plants, cuttings, buds or grafts may be packed or contained, they shall be subjected to a thorough process of fumigation, to be hereafter decided and approved by me in Privy Council for the purpose of completely destroying all animal or vegetable parasites which may have been imported on or along with the said plants, cuttings, buds or grafts.

And I do hereby order that this my proclamation shall come into force on the First Day of October, now next ensuing.

Given under my hand and the Broad Seal of this Island, at King's House, this Seventh Day of September, in the first year of His Majesty's Reign, Annoque Domini 1901.

By Command,

SYDNEY OLIVIER.
Acting Colonial Secretary.

A. W. L. HEMMING.

[L.S.]

By His Excellency Sir Augustus William Lawson Hemming, Knight Grand Cross of the Most Distinguished Order of Saint Michael and Saint George, Captain-General and Governor-in-Chief in and over the island of Jamaica and its Dependencies.

A PROCLAMATION.

Whereas by a Proclamation dated the Seventh day of September, and made under the authority of section 1 of Law 4 of 1884 (The Seeds and Plants Importation Law, 1884) it was among other things proclaimed and ordered that immediately on the importation into this island of any plants, cuttings, buds or grafts, and of any goods, packages, coverings or things in which such plants, cuttings, buddings or grafts, hereinafter referred to under the general term of 'proclaimed articles' might be packed, they shall be subjected to a thorough process of fumigation to be hereafter decided upon ;

And whereas the Governor in Privy Council has since decided upon adopting the process of fumigation hereinafter set forth for the purpose of completely destroying all animal or vegetable parasites which may have been imported on or along with the said proclaimed article ;

Now, therefore, I do hereby proclaim and order that the importation into this Island of all 'proclaimed articles' shall be subjected to the following conditions :-

All proclaimed articles shall be fumigated, and the work of fumigation shall be carried out by the staff of the Government Laboratory—a fumigatory box shall be employed for small operations, and a fumigatory chamber at the wharf for large. For ordinary purposes the dose of cyanide to be vaporised shall be one ounce for every 300 feet of cubic space and the exposure shall be one hour. For the more delicate plants half the above dose of cyanide shall be used and the exposure shall be half an hour only. Plants in Wardian cases shall be fumigated while still in the case. The Island and Agricultural Chemist shall be the authority to decide in any question connected with the fumigation of proclaimed articles which involves the exercise of any discretion.

Given under my hand and the Broad Seal of this Island, at King's House, this Fifteenth Day of October, in the First year of His Majesty's Reign, Annoque Domino 1901.

By Command,

SYDNEY OLIVIER,
Colonial Secretary.

7th January, 1902.

The Governor directs the publication, for general information, of the instructions issued for the guidance of Officers of the Government Laboratory and the Kingston Customs in regard to the manner in which imported plants, seeds, etc., shall be dealt with

By Command,

SYDNEY OLIVIER,

Colonial Secretary.

Instructions for the Guidance of Officers of the Government Laboratory and Kingston Customs in regard to the manner in which imported plants, cuttings, etc., and their coverings shall be dealt with

Immediately on the landing of any plants, cuttings or other articles specified in the Governor's Proclamation of the 7th September, 1901, published in the Government Notice No. 278, of the 10th of that month in the Jamaice *Gazette*, they shall be taken charge of by the Customs Officer who will give the Wharfinger or other party concerned, a receipt therefor, showing the time and date of delivery.

The Customs Officer shall at once notify the Government Chemist in writing, of the articles to be fumigated, stating the the approximate dimensions thereof and obtain his instructions as to the time at, and place to, which they are to be forwarded for fumigation.

The Customs Officer will then forward the articles accordingly in charge of a Customs Escort who will remain in attendance during the process of fumigation and afford, or provide, such assistance and labour as the Government Chemist or his officer in charge may require.

Immediately on receipt of the articles the Government Chemist (or his assistant) shall cause them to be fumigated in the manner and under the conditions prescribed by the Governor in Privy Council.

So soon as this shall have been done and a memorandum showing the time of receipt and delivery furnished to the Customs Escort, the articles shall be taken charge of by the Escort and conveyed to the King's Warehouse or other place, as arranged by the Landing Waiter.

The greatest care must be taken by the Officer in charge of the King's Warehouse to keep plants, cuttings, &c., alive and in good condition.

All expenses of removing the articles to the Government Laboratory, and thence to the King's Warehouse, with any expenses necessarily incurred in keeping the articles in good condition shall be met by the Importer, all such amounts being brought to account as King's Warehouse fees as provided by the Customs Regulations on the subject.

Plants, cuttings, &c., should not be forwarded to the King's Warehouse in cases where importers defray expenses of removal, labour, &c., (if any) at once, and at the same time arrange with the Customs Officer to take delivery of the articles immediately after fumigation This provision will refer more particularly to the plants, &c., brought by passengers and imported through the parcel post, &c.

Officers of Customs and of the Laboratory are required to exercise strict economy in arranging for the transport of the plants &c. and other expenses, so that the charge to the Importers may be as small as possible.

BRITISH GUIANA

The British Guiana Ordinance No. 21 of 1903 provides that the Governor-in-Council may prohibit or restrict the importation of plants etc. from any place. The proclamation under the Ordinance dated November 6, 1903, prohibits the importation of all cacao plants and cacao seeds, except cured cacao, from Surinam.

A further proclamation, dated March 8, 1909, deals with imported sugar-cane plants or cuttings. The Law (No. 21, 1903) and both proclamations are reproduced herewith.

In section 2, part 1, of No. 21—1903, power is given to prohibit the importation, and in section 2, part 2, to prescribe the conditions under which plants might be admitted. The proclamation of November 6, 1903, prohibits, absolutely, the importation of cacao from Surinam, except cured cacao. In the case of the proclamation of March 8, 1909, however, the second part of section 2 of 21—1903 is made use of; that is, conditions are prescribed under which certain plants, all sugar-canes, or cuttings thereof, are admitted.

These conditions are, briefly, inspection by Government Botanist, with power to destroy if the plants are found to be infested with any pest or disease. If permission is given for the plants to be removed, the cane cuttings must be planted apart from general cultivation and must be subject to inspection at any time for twelve months, and if any disease or pest is found, different from any known in the colony, they may be destroyed.

BRITISH GUIANA—ORDINANCE NO. 21 OF 1903.

An Ordinance to prevent the introduction into this Colony of Diseases of Plants.

Be it enacted by the Governor of British Guiana, with the advice and consent of the Court of Policy thereof, as follows:—

Short title.

1. This Ordinance may be cited as the Importation of Plant Diseases Prevention Ordinance, 1903.

Governor-in-Council may prohibit or restrict importation of plants, etc., from any place.

2.—(1) It shall be lawful for the Governor-in-Council on the recommendation of the Board of Agriculture, by Proclamation to be published in the *Gazette* to prohibit the importation of any seeds, plants, or any description of earth or soil, or any article packed therewith, or any package, covering or thing that may have come directly or indirectly from any country or place named in such Proclamation, which, in his opinion, are likely to be a means of introducing any plant disease from such country or place.

(2) In like manner the Governor-in-Council may prescribe the conditions under which alone the importation of any of the articles aforesaid shall be permitted that may have come directly or indirectly from any country named in such Proclamation.

(3) The Governor-in-Council may from time to time vary or revoke any such Proclamation

3. Any of the articles aforesaid coming as aforesaid from any country or place the importation from which is for the time prohibited, and any of the articles aforesaid arriving as aforesaid from a country or place the importation from which is permitted upon certain condition only, until and unless such conditions shall have been complied with to the satisfaction of the Comptroller of Customs shall be deemed to be prohibited goods within the meaning of the Customs Ordinance, 1884, and any such conditions as aforesaid shall be deemed to be restrictions within the meaning of the said Ordinance. Articles coming from a place from which importation prohibited or restricted to be deemed prohibited or restricted goods under Customs Ordinance.

4. So long as any Proclamation as aforesaid is in force, any of the articles aforesaid coming from parts beyond the sea may be deemed to have come from a place the importation from which is prohibited as aforesaid, and may be treated accordingly, unless the importer satisfies the Comptroller of Customs to the contrary. Burden of proof that goods not prohibited or restricted thrown on importer.

PROCLAMATION.

J. A SWETTENHAM,
Governor.

[L.S.]

By His Excellency Sir James Alexander Swettenham, Knight Commander of the Most Distinguished Order of St. Michael and St. George, Governor and Commander-in-Chief in and over the Colony of British Guiana, Vice-Admiral of the same. &c., &c., &c.

Whereas it is enacted by section 2 of the Importation of Plant Diseases Prevention Ordinance, 1903, that it shall be lawful for the Governor-in-Council, on the recommendation of the Board of Agriculture, to prohibit the importation of any seeds or plants which are likely to be a means of introduction into the colony any plant disease ;

And whereas the Board of Agriculture have recommended that the importation of all cacao plants and cacao seeds other than cured cacao from Suriname should be prohibited in order to guard against the introduction into this Colony of the disease known as 'Witch Broom' due to the fungus *Exoascus Theobromae* ;

I do hereby proclaim and make known that on and after the date of this Proclamation the importation into this Colony of cacao plants and cacao seeds other than cured cacao from Suriname is prohibited in accordance with the terms of section 2 of the Importation of Plant Diseases Prevention Ordinance, 1903.

Given under my hand and the Public Seal of the Colony, at the Guiana Public Buildings, Georgetown, Demerara, this Sixth day of November 1903, and in the Third year of His Majesty's Reign.

GOD SAVE THE KING.

By His Excellency's Command,

N. DARNELL DAVIS,
Acting Government Secretary.

PROCLAMATION.

BRITISH GUIANA.

F. M. HODGSON,
Governor.

By His Excellency Sir Frederick Mitchell Hodgson, Knight Commander of the Most Distinguished Order of Saint Michael and Saint George, Governor and Commander-in-Chief in and over the Colony of British Guiana, Vice-Admiral of the same. &c. &c. &c.

Whereas it is enacted by section 2 of the Importation of Plant Diseases Prevention Ordinance, 1903, that it shall be lawful for the Governor-in-Council, on the recommendation of the Board of Agriculture, to prohibit the importation of any seeds, plants, or any description of earth or soil, or any article packed therewith, which are likely to be a means of introducing into the Colony any plant disease and to permit their importation under certain prescribed conditions, and whereas the Board of Agriculture have recommended that the importation of all sugar-canes and cuttings thereof from Java, Australia, Fiji, Brazil, and the West Indian Islands, shall, owing to the prevalence of insect pests, fungoid and other diseases, be subject to the following conditions :—

(1) Sugar-canes or cuttings thereof from Java, Australia, Fiji, Brazil, and the West Indian Islands shall not be permitted to be imported in any description of earth or soil.

(2) All sugar-canes or cuttings thereof from the above-mentioned places to be inspected by the Government Botanist before being removed from the wharf or stelling at which they are landed and not to be removed from that place unless permitted by the Government Botanist in writing.

(3) If, on such inspection, the sugar-cane or cuttings thereof be found to be not free from pests or diseases of any sort already known to occur in the Colony the sugar-canes or cuttings to be treated as the Government Botanist may direct before removal from the wharf. If they are found to be infected with any pest or disease not commonly known in this Colony the sugar-canes or cuttings to be destroyed under the supervision of the Government Botanist or an officer of the Department of Science and Agriculture delegated for that purpose.

(4) If their removal is authorised by the Government Botanist, the sugar-canes or cuttings thereof to be planted in a nursery apart from the general cultivation and separate from other varieties of canes, and to be subject from time to time during twelve months from the date of importation to inspection by the Government Botanist or by an Officer of the Department of Science and Agriculture deputed by the Director for that purpose. If the canes are found at any inspection to be suffering from any pests or diseases already known in the Colony they shall be treated as may be directed by the Government Botanist, and if suffering from any pests or diseases not commonly known in the Colony they shall be rooted out and destroyed under the immediate supervision of the inspecting Officer

I do hereby proclaim and make known that on and after the date of this proclamation the importation into the Colony of sugar-canes or cuttings thereof from Java, Australia, Fiji, Brazil and the West Indian Islands shall be only under the abovementioned conditions in accordance with the terms of section 2 of the Importation of Plant Diseases Prevention Ordinance, 1903

Given under my Hand and the Public Seal of the Colony, at the Guiana Public Buildings, Georgetown, Demerara, this 8th day of March, 1909, and in the Ninth year of His Majesty's Reign.

GOD SAVE THE KING.

By His Excellency's Command.

CHARLES T. COX,
Government Secretary.

TRINIDAD AND TOBAGO.

An Ordinance passed in 1890 (No. 8 of 1890), entitled 'An Ordinance to prevent the introduction of Diseased Sugar-canes into the Colony', gives power to the Governor by proclamation to prohibit the importation of any sugar-canes grown in certain specified places in which sugar-cane diseases are known to exist. This was dated May 12, 1890.

Ordinance 28, 1894, which is given herewith, seems to have been passed to prevent introduction of coffee diseases, but it also provides for the total prohibition of plant importations.

An Ordinance to make provision for prohibiting the importation into the Colony of plants, seeds, berries and other articles affected or suspected to be affected with disease.

F. NAPIER BROOME,
[L.S.] Governor.

[8th September, 1894.]

Whereas it is apprehended that leaf and other kindred diseases in plants may be introduced into the Colony by means of plants, seeds, berries, earth, packages and otherwise: Preamble

And whereas it is expedient to protect the plantations in this Colony against such diseases:

Be it enacted by the Governor of Trinidad and Tobago with the advice and consent of the Legislative Council thereof as follows.—

1. This Ordinance may be cited for all purposes as "The Plant Protection Ordinance, 1894." Short title.

2 The introduction into the Colony of Coffee plants and uncured berries from Ceylon, Mauritius, Réunion, Fiji, Southern India, Sumatra, Java, Natal, or from such other places as may be included in any Proclamation under this Ordinance, is strictly prohibited. Prohibition of importation from certain places.

Power of Governor by Proclamation to prohibit importation of plants.

3. The Governor may from time to time with the advice of the Executive Council, by Proclamation to be published in the *Royal Gazette*, prohibit the importation into the Colony of any plants, seeds, berries, earth, soil, or any particular class of goods, packages, coverings, or other articles or things to be named and specified in such Proclamation which there shall be reason to believe to be affected with any disease, or which may be brought from any place outside the limits of the Colony where any such disease may exist or be suspected to exist, or which may be likely to be the means of communicating diseases to plants in this Colony.

Production of *Royal Gazette* evidence.

4. The production of a copy of the *Royal Gazette* containing a copy of such Proclamation shall be sufficient proof of the terms of such Proclamation and the publishing thereof.

Proclamation conclusive evidence as to statements therein.

5. A Proclamation issued and published under the provisions of this Ordinance shall be conclusive evidence in all Courts of Justice and elsewhere of the several matters and things therein set forth and contained.

Penalty.

6. Any person contravening the provisions of section 2 or of any Proclamation issued and published under the authority of this Ordinance shall be guilty of an offence against this Ordinance, and on summary conviction before a Stipendiary Justice of the Peace shall forfeit and pay any sum not exceeding Fifty Pounds sterling.

Power to seize prohibited imports.

7. Every article or thing imported into this Colony in contravention of this Ordinance or of any Proclamation under this Ordinance may be seized by any Officer of Customs or by any Commissioned or Non-commissioned Officer of Police or Police Constable, and shall be forfeited to Her Majesty, and may be destroyed or otherwise dealt with as the Governor may direct.

Procedure

8. Penalties under this Ordinance may be recovered before any Stipendiary Justice of the Peace, and the procedure for the recovery thereof shall be according to the Ordinance No. 5 of 1868, entitled 'An Ordinance respecting the Summary Administration of Justice,' or according to any Ordinance which may hereafter be passed regulating the Summary Administration of Justice.

Passed in Council this Twenty-seventh day of August, in the year of Our Lord one thousand eight hundred and ninety-four.

CHAS. J. ROOKS,
Acting Clerk of the Council.

Proclamation No. 10 of 1905 under this Ordinance was replaced by No. 13 of 1905, which is given herewith.

A PROCLAMATION.

Whereas by section 3 of the Plant Protection Ordinance 1894 (No. 28-1894) power is given to the Governor with the advice of the Executive Council to prohibit by proclamation the importation into this Colony of plants, seeds, berries, earth, soil or other articles or things which there shall be reason to believe to be affected with any disease or which may be brought from any place without the Colony where any such disease may exist or be suspected to exist.

And whereas it is expedient to prohibit, with certain exceptions, the importation into this Colony of cacao plants or portions of such plants or cacao beans from the mainland of South America.

Now, therefore, I, Henry Moore Jackson, Governor as aforesaid, with the advice of my Executive Council, do hereby prohibit the importation into this Colony from any part of the mainland of South America of cacao plants or portions thereof and of cacao beans except cured cacao beans from Venezuela and Colombia, and also fresh cacao beans and pods from the said countries provided that such latter beans and pods have been imported from a place free from disease and that they shall be carefully disinfected before distribution in this Colony.

Given under my hand and the Seal of the Colony at Government House in the Town of Port-of-Spain, this 15th day of April 1905.

By His Excellency's Command,

(Sgd.) WM. GORDON,
Acting Colonial Secretary.

Ordinance No. 126 is very similar to No. 28—1894. No. 127 provides for dealing with plant diseases and pests, and is very similar to Ordinance No. 20—1902 which is entitled 'An Ordinance to prevent the dissemination and to provide for the eradication of diseases affecting vegetation'. There is nothing in this Ordinance which provides for any control of imported plants which might be the means of introducing pests or diseases.

Ordinance No. 4—1907 refers to both No. 126 and No. 127, and provides that the Governor may by proclamation prescribe the conditions under which plants may be imported. This does not establish any system of fumigation such as that in Jamaica, nor any inspection such as that of British Guiana, but makes it possible to provide for either or both by proclamation.

BARBADOS.

The regulation and control of insect pests and fungoid diseases in Barbados is based on section 3 of the Trade (Amendment) Act, 1905 (1905—12), dated May 1, 1905, entitled *An Act to amend the Trade Act 1891 (1891—60)*, as follows:—

Be it enacted by the Governor, Council, and Assembly of this Island, and by the authority of the same, as follows:—

1. This Act may be cited as the Trade (Amendment) Act, 1905. Short title.

. . . .

3. (1) The Governor-in-Executive Committee may by order prescribe the conditions under which alone the importation of any seeds, plants or berries, or any description of earth or soil, or any article packed therewith, or any package, covering or thing that may have come directly or indirectly from any country or place named in such order, which, in the opinion of the Governor-in-Executive Committee are likely to be a means of introducing any plant disease from such country or place shall be permitted. Governor-in-Executive Committee may prohibit or restrict importation of plants etc., from any place.

Articles coming from a place from which importation prohibited to be deemed prohibited goods under Trade Act 1890.

(2) Any of the articles aforesaid arriving as aforesaid from a country or place the importation from which is permitted upon condition only, until and unless such conditions shall have been complied with to the satisfaction of the Comptroller of Customs, shall be deemed to be prohibited goods within the meaning of sections 48 and 49 of the Principal Act.

Burden of proof that goods not prohibited or restricted thrown on importer.

(3) So long as any order as aforesaid is in force any of the articles aforesaid coming from parts beyond the sea may be deemed to have come from a place the importation from which is permitted upon condition only, and may be treated accordingly, unless the importer satisfies the Comptroller of Customs to the contrary.

Construction of Act.

4. This Act shall be read and construed together with the Trade Act, 1891.

Read three times and passed the General Assembly the fifteenth day of November one thousand nine hundred and four.

F. J. CLARKE,
Speaker.

Read three times and passed the Legislative Council with amendments the twenty-first day of February one thousand nine hundred and five.

GEORGE C. PILE,
President

Amended by the Legislative Council and amendments agreed to by the House of Assembly the twenty-fifth day of April one thousand nine hundred and five.

F. J. CLARKE,
Speaker.

I assent

G. T. CARTER,
Governor.

1st May, 1905.

The following order dated May 13, 1909, prescribes the conditions under which plants may be imported into Barbados.

Made by the Governor in-Executive Committee under section 49 of the Trade Act, 1891 (1891—60), as amended by the Trade (Amendment) Act, 1900 (1900—3), and under section 3 of the Trade (Amendment) Act, 1905 (1905—12), prohibiting the importation of seed-cotton, etc, etc., and prescribing conditions under which plants, etc., may be imported.

1. Seed-cotton shall not be imported or brought into this Colony from any country.

2. Cotton seed shall not be imported or brought into this Colony from the U.S. America, Cuba, Porto Rico, Mexico, or Guatemala, except under a license from the Governor-in-Executive Committee permitting any quantity, not exceeding 500 ℔, to be imported at any one time, on the condition that such quantity is properly fumigated with carbon bisulphide before shipment, and that it will be fumigated or disinfected, or both, at the discretion of the Superintendent of Agriculture, or his Assistant, on its arrival in this Colony.

3. Cotton seed, from which oil is to be extracted, shal not be imported or brought into this Colony, except under the following conditions:—

(*a*) Such seed shall be fumigated either at the Government fumigatorium or in a building licensed for that purpose by the Governor-in-Executive Committee. Such seed shall be conveyed by the importer, immediately after it has been landed, to the Government fumigatorium or to the licensed building, under the supervision of an officer of the Local Department of Agriculture, who shall be immediately notified thereof by the Comptroller of Customs, and the fumigation shall be done at the expense of the importer in the presence, and to the satisfaction, of the Superintendent of Agriculture or his assistant, or:

(*b*) Such seed may be fumigated on board any ship conveying the seed, or in any building, licensed for the purpose, by means of sulphur dioxide gas generated and applied by means of a Clayton disinfector or similar apparatus at the expense of the importer and to the satisfaction of the Superintendent of Agriculture or his assistant, or:

(*c*) In lieu of fumigation, the bags or packages containing such seed, shall be marked, before being landed, with a red cross one foot in length, and shall be stored in a building licensed by the Governor-in-Executive Committee, which shall be distinct and separate from any building in which seed to be used for planting is stored. Such seed shall be conveyed to the licensed building at the expense of the importer immediately on being landed, under the supervision of an officer of the Local Department of Agriculture who shall be immediately notified thereof by the Comptroller of Customs.

(*d*) All bags or packages which have contained cotton seed stored in any building licensed by the Governor-in-Executive Committee, or any other article taken into such building shall, immediately on removal from such building, be placed in a steam oven and there kept at a temperature of not less than 212° F. for fifteen minutes, or placed in briskly boiling water and kept therein for a period of not less than fifteen minutes.

(*e*) The Superintendent of Agriculture, or his assistant, shall have power, at any time during any week day between the hours of 7 a.m. and 4 p.m., to visit and inspect any building licensed for the purpose of storing seed, which is not to be fumigated.

4. All plants, cuttings, buds, grafts, bulbs, roots, seeds, and also fruit and vegetables intended for propagation and not for consumption as food, imported into this Colony from any country, together with the packages, boxes, wrappers, soil, or anything whatsoever in which they are imported, shall be delivered by the importer to the Comptroller or other Officer of Customs, or the Colonial Postmaster or other Officer of the Post Office in order that they may be fumigated or disinfected or both fumigated and disinfected. Where, however, in the opinion of the Superintendent of Agriculture, or his assistant, fumigation or disinfection or both fumigation and disinfection, is not sufficient to destroy any insect pest or fungoid disease on any plant, cutting, bud, graft, bulb, root, seed, fruit and vegetable, or other article sent him for fumiga-

tion, he shall cause such article to be destroyed. In the case of the importation of any plant or part thereof, which in the opinion of the Superintendent of Agriculture should be grown apart from other plants of a similar description, he shall, if he think fit, require such plant, or part thereof, to be so cultivated, and such plant or plants shall be subject from time to time during twelve months from the date of importation, to inspection by himself or one of his assistants, and if any such plant is at any time found on inspection to be suffering from any pest or disease already known in the Colony, it shall be treated as directed by the Superintendent of Agriculture, and if suffering from any pests or disease not commonly known in the Colony, it shall be rooted out and destroyed, under the immediate supervision of the Superintendent of Agriculture or his assistant.

5. Immediately on the landing of the imported articles or other things mentioned in the preceding paragraph, other than those imported through the Post Office, they shall be taken charge of by the Comptroller of Customs or other Officer of Customs who shall give the party a receipt showing the time and date of delivery. Where they are imported through the Post Office, they shall be taken charge of by the Colonial Postmaster or other Officer of the Post Office, who shall also give the party a receipt showing the time and date of delivery.

6. All expenses of removing the articles or things mentioned in paragraph 4 to the place of fumigation or disinfection and thence to the Customs warehouse or General Post Office, and any expense necessarily incurred in keeping the articles in good condition, or in destroying any articles when they are so ordered by the Superintendent of Agriculture shall be met by the importer, who shall pay all such amounts to the Comptroller of Customs or to the Colonial Postmaster as the case may be.

7. The expenses mentioned in paragraphs 3 and 6 may be recovered in a summary manner before any Police Magistrate.

8. This order shall not apply to any of the abovementioned articles when imported by or for the Imperial Commissioner of Agriculture for the West Indies for scientific purposes, provided that the Imperial Commissioner of Agriculture for the West Indies so notifies the Comptroller of Customs or the Colonial Postmaster.

9. The order made by the Governor-in-Executive Committee on the eighteenth day of March 1909, under section 49 of the Trade Act, 1891 (1891—60) as amended by the Trade (Amendment) Act, 1900 (1900—3) and under section 3 of the Trade (Amendment) Act, 1905 (1905—12) is hereby revoked.

Made by the Governor-in-Executive Committee on the thirteenth day of May, 1909.

EDWD. T. GRANNUM,
Colonial Secretary, Acting.

NOTE :—Any person, who contravenes any of the provisions of the above Order is under section 49 of the Trade Act, 1891 (1891—60), liable to a penalty not exceeding £100 sterling.

This Order, it will be seen, prohibits the importation of seed-cotton, regulates the importation of cotton seed for planting and for oil-making, and prescribes the conditions under which plants may be imported. It provides for fumigation and disinfection and for the destruction of plants infested by any pest or disease which, in the opinion of the Superintendent of Agriculture, would not be killed by the ordinary processes of fumigation or disinfection. It also gives the Superintendent of Agriculture power to direct, if he think fit, that plants must be grown apart for a period of twelve months, during which time they must be inspected by him or his assistant, and at the end of that period they may be destroyed.

The Order gives the Agricultural Superintendent no discretion in respect of admitting plants without treatment; all imported plants must be treated, except plants imported by the Imperial Commissioner of Agriculture for scientific purposes.

THE WINDWARD ISLANDS.

GRENADA.

The Grenada Ordinance, No. 14 of 1891, which was repealed in 1897, provided that it should be lawful for the Governor from time to time to prohibit the importation of plants by Proclamation from any country or place named in the Proclamation which were likely to be a means of introducing diseases in plants; also to prescribe the conditions under which alone plants, etc., the importation of which is not absolutely prohibited, that may have come directly or indirectly from such place or country, may be admitted.

This Ordinance was repealed, because it was considered that section 79 of the Customs Ordinance was sufficient for the object in view.

This section is as follows:

> 79 The Governor-in-Council may at any time by notice in the *Gazette* absolutely prohibit the importation into this Colony of any goods or articles of any kind whatsoever, and may by subsequent notice revoke such prohibition, either wholly or in part; and any ship bringing such goods into the Colony after such notice shall, subject to an appeal to the Governor-in-Council, be liable to forfeiture, and the goods shall be forfeited, and the importer or any person keeping or concealing the goods shall be liable to a penalty not exceeding one hundred pounds.

The following Order with respect to the importation of cacao was issued on March 21, 1902:—

> Under the authority of section 79 of the 'Customs Ordinance 1891' the Governor-in-Council is pleased to absolutely prohibit the importation into this colony from any country or place in South America, lying to the East or South of the Isthmus of Panama, of any pod, seed, or plants of Cocoa, or of any part or portion whatsoever of a cocoa tree.

Ordinance No. 17 of 1900, dated November 27, 1900, is entitled 'An Ordinance to prevent the introduction and to provide for the eradication of diseases affecting vegetation, and for other purposes.'

This Ordinance is the same in its provisions with regard to insects and diseases as the Trinidad Ordinance No. 20, 1903. It makes no reference to imported plants as a source of disease of plants, and is calculated more to deal with pests and diseases already established in the island than to prevent the introduction of others.

No. 7 of 1906, entitled 'An Ordinance to prevent the introduction into this Colony of Diseases of Plants,' is dated June 1, 1906.

GRENADA.

An Ordinance to prevent the introduction into this Colony of Diseases of Plants.

I Assent.

R. B. LLEWELYN,
Governor.
1st June, 1906.

[*1st June, 1906.*]

Be it enacted by the Governor with the advice and consent of the Legislative Council of Grenada as follows :—

Interpretation of terms.

1. In this Ordinance the expressions hereinafter mentioned shall have the meanings assigned respectively to them as follows :—

(*a*) 'Plants' includes growing plants, cuttings, buds and grafts, bulbs, roots, seeds and berries, and also fruit, and vegetables intended for propagation and not for consumption as food.

(*b*) 'Packages' includes boxes, coverings, wrappers, soil or anything whatsoever in which plants are imported.

(*c*) 'Port of Entry' means the port of St. George and any other port or place in this Colony appointed by the Governor for the importation of plants.

(*d*) 'Treasurer' includes every Officer of Customs.

(*e*) 'Agricultural authority' includes every person acting in the aid or under the direction of the Agricultural authority.

(*f*) 'Imported' means brought into this Colony by any channel whatsoever, including the 'Parcels Post.

(*g*) 'Importer' includes the Owner and his agents and servants.

Appointment of Agricultural authority.

2. The Governor may from time to time appoint some person to be the Agricultural authority under this Ordinance.

Governor-in-Council may by Proclamation prohibit importation of an plants, &c

3. (1) The Governor-in-Council may by Proclamation to be published in the *Gazette*, absolutely prohibit the importation, directly or indirectly from any country or place named in such Proclamation of any plants or any earth or soil, or any article packed therewith, or any packages, or other articles or thing which, in the opinion of the Governor-in-Council, are or is likely to be a means of introducing any

plant disease from such country or place. Any Proclamation issued hereunder shall remain in force for such time as may be mentioned in that or any subsequent Proclamation.

(2) Any of the articles aforesaid, the importation of which into this Colony has been prohibited by any Proclamation as aforesaid, shall upon importation into this Colony be forthwith seized and forfeited to His Majesty, and the importer shall be guilty of an offence against this Ordinance. Consequences of importing prohibited plants &c.

(3) So long as any such Proclamation is in force, any of the articles aforesaid coming from parts beyond the seas may be deemed to have come from a place the importation from which is prohibited as aforesaid, and may be treated accordingly, unless the importer satisfies the Treasurer to the contrary. When burden of proof thrown on importer of plants &c.

4. Suitable apparatus for the fumigation or disinfection of plants shall be provided by the Government for use at the Port of St. George's and also at any other Port of Entry which may be appointed by the Governor for the importation of plants; and such apparatus hereinafter called 'the Fumigatorium' shall be under the care, control and management of the Agricultural authority. Fumigating and disinfecting apparatus.

5. (1) Hereafter, no plants whatsoever nor the packages thereof shall be allowed to be imported into this Colony, except under the conditions herein prescribed. All imported plants to be fumigated or disinfected.

(2) No imported plants nor the packages thereof shall be landed in this Colony elsewhere than at a Port of Entry.

(3) All imported plants and the packages of the same imported into this Colony shall, upon their arrival be delivered up by the importer to the Treasurer for conveyance to the Fumigatorium there to be dealt with by the Agricultural authority; and the Treasurer shall thereupon give to the importer a receipt showing the time and date of such delivery Procedure upon importation.

(4) Any person who imports any plants or packages as aforesaid contrary to the provisions of this section and all such articles so imported may be forthwith seized and forfeited to His Majesty.

6. The process of fumigation or disinfection or both shall be (subject to any Rules or Regulations made by the Governor-in-Council) carried out in such manner and under such conditions as the Agricultural authority may consider adequate for the destruction of any insect or vegetable pests which may possibly be on such plants; and no liability shall attach to the Government or to the Agricultural authority in respect of any damage occasioned by such fumigation or disinfection. Process of fumigation or disinfection.

7. All plants and packages shall be returned by the Agricultural authority to the Treasurer as soon as practicable after fumigation or disinfection and shall be removed by the importer within forty-eight hours thereafter and failing the removal of the same within such time as aforesaid the Treasurer shall be at liberty to order their destruction. Removal of plants after fumigation or disinfection.

8. The expenses of removing plants and other articles to and from the Fumigatorium, and of their fumigation or disinfection shall be defrayed by the Government, but the Government may recover from the importer these and any other expenses necessarily incurred in keeping the plants in good condition. Expenses of removal &c., may be recovered from importer.

Power for Agricultural authority to inspect plants after delivery to importer.

9. The Agricultural authority may direct the importer, who in such case is hereby required to comply with such direction, to keep him informed as to the disposal of any plants after fumigation or disinfection, and may visit and examine them at any time if necessary.

Seizures to be notified in *Gazette*.

10. The seizure and forfeiture of all articles seized under any of the above provisions shall be notified in the *Gazette* so soon as practicable after the seizure; and any such articles so forfeited may be destroyed or otherwise disposed of as the Governor may direct.

Power for Treasurer to search for, seize and remove plants illegally imported.

11. It shall be lawful for the Treasurer and for any person acting for him under his authority, to enter any building, place or premises and to search for any plants or other articles which shall have been imported into this Colony in contravention of this Ordinance and which he has reason to suppose are in or on such building, place or premises, and for the purpose of such search to break open if necessary any door, chest, box, package or parcel and to seize such plants or other articles as aforesaid and to remove or secure the same in such way or place and in such manner as he deems most advisable.

Rules and Regulations.

12. The Governor-in-Council shall have power to make Rules and Regulations for more effectually carrying out the provisions and intentions of this Ordinance.

Penalty for offences under this law.

13. Any person who is guilty of an offence against this Ordinance or against any rule or Regulation made hereunder shall on conviction be liable to a penalty not exceeding the sum of Twenty Pounds for every offence.

Procedure in prosecutions.

14. All proceedings under this Ordinance against offenders shall be taken in the name of the Treasurer; and the mode of procedure shall be according to any law in force for the time being regulating proceedings before Magistrates.

Short title.

15. This Ordinance may be cited as 'The Plant Protection Ordinance, 1906'.

Passed the Legislative Council this twenty third day of May in the year of our Lord one thousand nine hundred and six.

T. T. DYER,
Clerk of Councils.

This Ordinance is a good example of the modern law giving power to prohibit or restrict the importation of plants and providing (sec. 5) for the fumigation or disinfection of all imported plants. It allows (sec. 6) latitude to the agricultural authority in prescribing the exact treatment in each case, but does not permit the discretion of this officer to be used to exempt plants from fumigation.

ST. VINCENT.

The Plant Protection Ordinance 1895 (No. 19 of 1895) provided for total prohibition of any or all plants from any or all places, and for the seizure of any goods, packages, etc., etc., which it seemed reasonable to the Treasurer to suspect may be liable to convey diseases to plants. This was repealed by No. 5 of 1905, which in turn was repealed by No. 9 of 1906,

entitled 'An Ordinance to prevent the introduction into this Colony of diseases of plants', and dated August 2, 1906.

This law in all its provisions is like the Grenada Law (7—1906) just quoted.

The following notice was issued in 1906, and appeared in the St. Vincent *Gazette*, No. 33 of that year:—

The Governor-in-Council under the authority of section 5 of 'The Importation of Plant Diseases Prevention Ordinance 1906' has this 17th day of November, 1906 been pleased to absolutely prohibit the importation into this Colony, directly or indirectly, from any of the countries or places named in the subjoined Schedule the articles appearing opposite thereto.

SCHEDULE

From Ceylon, Natal, South India, Mauritius, and the Straits Settlements. Of all plants, seeds, berries, and any earth, soil, or vegetable matter used for packing or covering the same.

From South America. Of all cacao plants or trees and parts or portions of such plants or trees and any earth, soil, or vegetable matter used for packing or covering the same.

From the Colony of Trinidad and Tobago. Of any suckers, roots, fruit or any other portions of a banana-plant and any earth, soil, or vegetable matter used for packing or covering the same.

ST. LUCIA.

An Ordinance to prevent the introduction into this Colony of Diseases of Plants.

[No. 12 of January 22, 1910.]

Be it enacted by the Governor with the advice and consent of the Legislative Council of Saint Lucia, as follows:—

1. This Ordinance may be cited as the Plants Protection Ordinance, 1910. Short title.

2. In this Ordinance the expressions following shall have the meanings hereby respectively assigned to them, that is to say:— Interpretation of terms.

(*a*) 'Agricultural authority' means the Agricultural Superintendent and includes any person acting on his behalf by his direction.

(*b* 'Disinfection' includes 'fumigation.'

(*c*) Imported' means brought into this Colony by any channel whatsoever.

(*d*) 'Importer' includes the owner and consignee and their agents and servants.

(*e*) 'Packages' includes boxes, coverings, wrappers, earth, soil or anything whatsoever in which plants are imported.

(*f*) 'Plants' includes growing plants, cuttings, buds grafts, bulbs, roots, seeds, and berries, and also fruit and vegetables intended for propagation and not for consumption as food.

(*g*) 'Treasurer' includes every Officer of Customs and for the purpose of dealing with the importation of plants and packages through the Post Office, includes the Post Master and any Official of the Post Office acting on his behalf by his direction or those of the Governor.

Importation of plants prohibited by Proclamation

3. (1) The Governor-in-Council may by Proclamation to be published in the *Gazette* absolutely or conditionally prohibit the importation directly or indirectly from any country or place named in such Proclamation of any plants or any earth or soil, or any article packed therewith or any packages or other articles or things which in the opinion of the Governor-in-Council are or is likely to be a means of introducing any plant disease into this Colony.

(2) Any Proclamation issued hereunder or under the Plant Protection Ordinance 1895, shall remain in force for such time as may be mentioned therein or in any subsequent Proclamation hereunder, and may be varied or revoked by the like authority.

(3) Any such plants, packages, earth, soil, articles or things imported into this Colony may be deemed to be a prohibited importation and may be treated accordingly, unless the Importer satisfies the Treasurer to the contrary.

Imported plants.

4. No plants whatsoever nor the packages thereof shall be imported into this Colony except under the following conditions :—

To be landed at port of Entry.

(1) All such plants and packages shall be landed at the Port of Castries, except when permission has been obtained under section five hereof to land the same at any other place.

And delivered up for disinfection.

(2) All such plants and packages shall be delivered up by the Importer to the Treasurer who shall cause them to be conveyed to the place of disinfection there to be dealt with by the Agricultural Authority, and the Treasurer may also for such purpose take charge of any such plants and packages immediately on their arrival in the Colony and prior to the delivery thereof to the Importer.

Receipt to be given.

(3) Upon such delivery the Treasurer shall give to the Importer a receipt showing the time and date of such delivery.

Permission to land plants elsewhere than at Castries.

5. The Governor may by permission in writing

(1) allow any Importer to land any plants and packages at any other place than the Port of Castries to be specified in such permission on being satisfied that the special permission of the Treasurer where necessary under the Customs Ordinance, 1888, has been obtained, and

(2) allow the importation of plants for scientific purposes without their being subject to disinfection on the application of the Imperial Commissioner of Agriculture or of the Agricultural Authority.

6. Suitable apparatus for the disinfection of plants shall be provided by the Government at the Port of Castries; and such apparatus shall be under the care of the Agricultural Authority. Disinfecting apparatus.

7. (1) The process of disinfection shall be carried out in such manner and under such conditions as the Agricultural Authority may consider adequate for destruction of any vegetable or insect pests which may possibly be on or amongst such plants or packages subject to any regulations made hereunder by the Governor-in-Council. Process of disinfection.

(2) No liability shall attach to the Government or to the Agricultural Authority in respect of any damage occasioned by such disinfection.

8. All plants and packages shall be removed from the place of disinfection by the Importer within twenty-four hours after he has been required by the Agricultural Authority to remove the same, and failing such removal the Agricultural Authority shall be at liberty to order the destruction of such plants and packages or to deal otherwise with them at his discretion. Removal of plants after disinfection.

9. The expenses of removal to and from the place of disinfection shall be borne by the Importer, and the Government may recover from the Importer such expenses as well as any expenses necessarily incurred in keeping the plants in good condition. Provided always that if the importation exceeds in bulk twenty cubic feet or in weight half a ton, then the Importer shall also bear the expenses of disinfection. Provided also that if plants are landed at any place other than the Port of Castries by special permission of the Governor then the Importer shall in addition pay all the expenses of disinfection including the transport of apparatus and the attendance of the Agricultural Authority and shall provide any labour necessary to carry out such disinfection. Expenses of removal, &c.

10. The Agricultural Authority may require the Importer to keep him informed as to the disposal of any plants after disinfection and may visit and examine them at any time, if necessary. Inspection of plants after removal.

11. (1) Where in the opinion of the Agricultural Authority disinfection is not sufficient to destroy any insect pest or fungoid disease on any plant sent him for disinfection, he shall cause such plant to be destroyed.

(2) Where in the opinion of the Agricultural Authority any imported plant or part thereof should be grown apart from other plants of a similar description, he shall, if he think fit, require such plant or part thereof to be so grown and shall, from time to time during twelve months from the date of the importation of such plant, subject the same to inspection by himself or as he shall direct, and if any such plant is at any time found on inspection to be suffering from any pest or disease already known in the Colony it shall be treated as directed by the Agricultural Authority and if suffering from any pest or disease not already known in the Colony it may be destroyed under the immediate supervision of the Agricultural Authority.

12. All plants, packages or other articles imported into this Colony contrary to the provisions of this Ordinance or of any Proclamation issued hereunder, or under the Plant Seizure of plants.

Protection Ordinance, 1895, may be seized and forfeited, and may be destroyed or otherwise dealt with as the Governor may direct.

Powers of search for plants illegally imported.

13. It shall be lawful for the Treasurer or for any person acting under his authority if he shall suspect that any plants packages or other articles have been imported contrary to the provisions of this Ordinance or to any Proclamation issued hereunder, or under the Plant Protection Ordinance, 1895, to enter any building, place or premises, and to search for any such plants, packages or articles, and for the purpose of such search to break open, if neccessary, any exterior or interior door, or any chest, box or other receptacle, and to seize such plants, packages or other articles as aforesaid, and to remove or secure the same in such way or place and in such manner as he deems advisable.

Penalties.

14. (1) Every person who shall do or omit to do anything which is by this Ordinance, or by any Regulation made hereunder, or by any Proclamation made hereunder, or under the Plant Protection Ordinance, 1895, forbidden or required to be done, or shall assault, resist, hinder, prevent or obstruct any person acting under and by the authority of this Ordinance, or of any Proclamation made hereunder, or under the Plant Protection Ordinance, 1895, shall be guilty of an offence against this Ordinance and shall on conviction be liable to a penalty not exceeding twenty pounds

Procedure.

(2) All proceedings under this Ordinance against offenders shall be taken in the name of the Treasurer, and the mode of procedure shall be according to the provisions of any Ordinance for the time being regulating proceedings before Magistrates.

Power to make Regulations.

15. The Governor-in-Council may make Regulations for the better carrying out of all or any of the provisions of this Ordinance.

Repeal.

16. The Plant Protection Ordinance, 1895, is hereby repealed.

The present law (No. 12, 1910, January 22) follows closely on the Grenada (7--1906) and St. Vincent (9--1906) Ordinances already considered, and it replaces the previous law No. 5 of 1895.

The earlier law (5 -1895) provided for total prohibition of the importation of plants suspected of disease. A proclamation issued by the Administrator, under date of February 2, 1907, provided for the fumigation of imported plants, under the direction of the agricultural authority, before they could be admitted to the colony.

The latest law is the first of these Ordinances to employ the term disinfection as a general term including the application of both insecticides and fungicides, and perhaps more than one of each. The kind of treatment, if any, is left to the discretion of the agricultural authority and, on the whole, the Ordinance seems to be very thorough and complete.

THE LEEWARD ISLANDS.

Each Presidency of the Leeward Islands, with the exception of the Virgin Islands, has enacted legislation to provide for the fumigation of imported plants immediately on their being landed at the port of entry.

The following are the numbers and dates of the Ordinances providing for the fumigation of imported plants now in force :—

Dominica	No. 9 of 1904	July 27, 1904.
Antigua	No. 5 of 1905	May 31, 1905.
Montserrat	No. 1 of 1906	March 27, 1906.
St. Kitts-Nevis	No. 3 of 1907	May 25, 1907.

All the Presidencies of the Leeward Islands had laws passed in 1897-98, which gave power of total prohibition. In Dominica, this early law (No. 3 of 1898) was repealed by No. 9 of 1904, and was afterward replaced by No. 6 of 1907. The earlier laws are still in force in the other islands. The Virgin Islands have no Ordinance dealing with imported plants more recent than No. 3 of 1897.

DOMINICA.

[L.S.] I assent.
CHARLES T. COX,

Acting Governor.

No. 9 of 1904.

27th July, 1904.

An Ordinance to provide for the fumigation of plants imported into this Presidency

Be it ordained by the Governor and Legislative Council of Dominica as follows : -

1. This Ordinance may be cited as 'The fumigation of plants Ordinance, 1904.' Short Title.

2. In this Ordinance the expressions hereinafter mentioned shall have the meanings assigned respectively to them as follows :— Definition of terms.

(*a*) 'Plants' includes growing plants, cuttings, buds, and grafts, bulbs, roots and seeds, and also fruit and vegetables intended for propagation and not for consumption as food

(*b*) 'Packages' includes boxes, coverings, wrappers or anything whatever in which plants are imported.

(*c*) 'Port of entry' means the Port of Roseau and any other port or place in this Presidency appointed by the Governor for the importation of plants.

(*d*) 'Treasurer' includes every Officer of Customs.

(*e*) 'Agricultural authority' means the Curator of the Botanical Gardens, and includes every person acting in his aid or under his direction.

(*f*) 'Imported' means brought into this Presidency by any channel whatsoever, including the 'Parcels Post.'

(*g*) 'Importer' includes the owner and his Agents and Servants.

Port of entry.

3 The Governer may by Proclamation appoint one or more places (besides the Port of Roseau) as Ports of entry for the importation of plants.

All imported plants to be fumigated

4. All plants imported into this Presidency together with the packages in which they are contained shall, subject to the discretion of the Agricultural authority, be fumigated.

By Agricultural authority

5. All plants so imported shall be delivered up by the Importer to the Treasurer who shall cause them to be conveyed to the place of fumigation there to be dealt with by the Agricultural authority.

Place of landing.

6. No imported plants shall be landed elsewhere than at a Port of Entry.

Fumigating apparatus

7. Suitable apparatus for the fumigation of plants shall be provided by the Government at the Botanical Gardens for use at the Port of Roseau ; and also at any other Port of entry appointed by the Governor for the importation of plants ; and such apparatus shall be under the care, control and management of the Agricultural authority.

Process of fumigation.

8 The process of fumigation shall be carried out in such manner and under such conditions as the Agricultural authority may consider adequate for the destruction of any vegetable or insect pests which may possibly be on such plants, subject to any rules or regulations by the Governor in that behalf.

Removal of plants after fumigation.

9. All plants shall be removed by the owner from the fumigation place after disinfection immediately upon his being required to do so by the Agricultural authority.

Disposal of plants after fumigation.

10. The Agricultural authority may require the importer to keep him informed as to the disposal of any plants after fumigation, and may visit and examine them at any time if necessary.

Expenses of removal.

11. The expenses of removal to the place of fumigation (except it be in large quantities) and of the fumigation of plants shall be at the expense of the Government, but the Government shall incur no liability in respect of any risk attending fumigation.

Penalties

12. Any plants imported contrary to the provisions of this Ordinance shall be forfeited.

13. Offences against this Ordinance shall be punishable under the provisions of section 83 of 'The Trade and Revenue Act, 1894', upon summary conviction before a District Magistrate.

14. The provisions of the 'Trade and Revenue Act, 1894', shall apply to this Ordinance as regards the search for, seizure and disposal of plants imported contrary to its provisions.

Rules.

15. The Governor-in-Council shall have power to make Rules and Regulations for more effectually carrying out the provisions and intentions of this Ordinance.

16. 'The Plants Protection Act, 1898', is hereby repealed. Repealing clause.

W. H. PORTER,
President Legislative Council.

Passed the Legislative Council of Dominica the twelfth day of July, 1904.

J. A. PINARD,
Clerk Legislative Council.

Dated at Antigua the 27th day of July, 1904, in the Fourth year of His Majesty's Reigr.

Duly published in the town of Roseau this 30th day of July, 1904.

C. MUSGRAVE,
Provost Marshal.

This is the first legislation, providing specifically for the fumigation of imported plants, to be enacted in the West Indies, except that of Jamaica, and in its provisions it follows closely on the Jamaica laws.

The Ordinance, it will be seen, provides for the Short Title Definition of Terms, and the designation of the Port of Entry in sections 1, 2 and 3. Section 4 gives the agricultural authority power to exercise discretion as to the fumigation of plants, and section 8 provides that 'the process of fumigation shall be carried out in such manner and under such conditions as the agricultural authority may consider adequate for the destruction of any vegetable or insect pests which may possibly be on such plants, subject to any rules or regulations by the Governor in that behalf'.

It would seem that these two sections taken together provide for all the emergencies which may arise in connexion with the fumigation of imported plants.

The Ordinance also provides (section 10) that the importer may be required to keep the agricultural authority informed as to the disposal of the plants and to allow the agricultural authority to inspect them from time to time.

The term fumigation, it is to be presumed, may be regarded as including disinfection in case the presence of fungoid diseases is known or even suspected, and it should be possible also to construe it to mean other fumigation or disinfection than that with hydrocyanic acid gas, since it is stated (sec. 4) that all plants imported into the Presidency shall, subject to discretion, be fumigated, and also (sec. 8) that the process of fumigation shall be carried out in such manner as the agricultural authority may consider adequate for the destruction of any vegetable or insect pests, which may possibly be on such plants. Vegetable pests may be taken to mean fungoid diseases, and the process of disinfection, to mean treatment with corrosive sublimate or Bordeaux mixture, if in the opinion of the agricultural authority either of these were adequate for the destruction of such diseases. Also while hydrocyanic acid gas is a satisfactory fumigant for dealing with certain insect pests likely to be present on nursery plants, it often happens that an agent such as carbon disulphide would

be more effectual in the case of seeds, bulbs, and especially in soil at the roots of plants.

These two sections (2 and 8) then would seem to cover the same points as those contained in the Barbados fumigation law, in the words fumigated or disinfected or both fumigated and disinfected.

Ordinance No. 9 —1904 does not provide for total prohibition of importation of plants, but this is supplied in No. 6 of 1907. Further, the Ordinance does not give power to the agricultural authority to destroy plants which are found on arrival to be so badly diseased or infested that the means of treating them are not likely to be sufficiently efficacious to prevent the introduction of such diseases or pests.

It may be argued, however, that sufficient protection is ensured by the provision which enables the agricultural authority to be kept informed as to the disposal of the plants, and to be allowed to inspect them from time to time, on the assumption that the owner would be willing to destroy them if they showed signs of the development of diseases or pests which were new to the island, or which were known to be difficult or impossible to control. Section 15, which reads: 'The Governor-in-Council shall have power to make Rules and Regulations for more effectually carrying out the provisions and instructions of this Ordinance', might be taken as providing for this difficulty, since it is obviously the intention of the Ordinance to prevent the introduction into the island of diseases and pests of plants which may be injurious to the agricultural interests.

[L.S.] DOMINICA.

I assent.

BICKHAM SWEET-ESCOTT

Governor.

12th April, 1907.

No. 6 of 1907.

An Ordinance to provide against the importation of articles likely to introduce disease among plants.

Be it ordained by the Governor and Legislative Council of Dominica as follows:—

Short Title.

1. This Ordinance may be cited as 'The Plants Protection Ordinance, 1907'.

Power to prohibit by proclamation the importation of plants, &c.

2. Anything contained in 'The Fumigation of Plants Ordinance, 1904', to the contrary notwithstanding, it shall be lawful for the Governor-in-Council, by proclamation to be published in the *Official Gazette*, to prohibit absolutely the importation, directly or indirectly into this Presidency from any country or place named in such proclamation, of any plants, cuttings, bulbs, roots, seeds, or berries, or any earth or soil, or any article packed therewith, or any packages or other articles or things which in the opinion of the Governor-in-Council are or is likely to be a means of introducing any plant disease from such country or place And any proclamation issued hereunder shall remain in force for such time as may be mentioned in that or any subsequent proclamation.

3. Any of the articles or things aforesaid, the importation of which into this Presidency has been prohibited by any proclamation as aforesaid, shall, upon importation, be forthwith seized by any Treasury or Revenue Officer or by any member of the Police Force, and shall be forfeited to His Majesty, and shall be destroyed or otherwise dealt with as the Governor may direct. And the importer shall be guilty of an offence and liable on Summary Conviction before a District Magistrate to pay a sum not exceeding Fifty pounds (£50). Power to seize prohibited imports. Penalty for importing prohibited imports.

4. So long as any proclamation is in force any of the articles or things aforesaid coming from parts beyond the seas may be deemed to have come from a place the importation from which is prohibited as aforesaid and may be treated accordingly unless the Importer satisfies the Treasurer or the Magistrate, as the case may be, to the contrary. Onus of proof on importer.

DOUGLAS YOUNG,
Administrator.
President Legislative Council.

Passed the Legislative Council of Dominica the twenty eighth day of March, 1907.

J. A. PINARD,
Clerk, Legislative Council.

Dated at Antigua, the twelfth day of April, 1907, in the Seventh year of His Majesty's Reign.

Duly published in the Town of Roseau this twenty-third day of April, 1907.

C. MUSGRAVE,
Provost Marshal.

Proclamation dated February 5, 1909, under No. 6 of 1907 prohibits the importation into Dominica of all plants from Dutch Guiana which are likely to be a means of introducing any disease from that country.

ANTIGUA.

The Fumigation of Plants Ordinance, Antigua, No. 5 of 1905, dated May 31, 1905, is very similar in all its provisions to the Dominica Ordinance No. 9—1904, covering all the points mentioned above; and as in Dominica, there is no definite statement that the importation of all plants from any country may be prohibited. A Law (No. 4—1897, June 4, 1897) is still in force in Antigua, providing for the total prohibition of imported plants as in Montserrat, St. Kitts-Nevis, and the Virgin Islands.

[L.S.] ANTIGUA.

I assent.

GEO: MELVILLE,
Administering the Government,
Leeward Islands
4th June, 1897.

No. 4 of 1897.

An Act to provide against the importation of articles likely to introduce disease among plants.

Whereas it is apprehended that leaf and other kindred diseases in plants may be imported by means of plants, seeds, berries, earth, packages and otherwise;

And whereas it is expedient to protect the plantations of this Presidency against such introduction of disease;

Be it enacted by the Governor and Legislative Council of Antigua as follows: —

Short title. 1. This Act may be cited for all purposes as 'The Plants Protection Act, 1897.'

Prohibition of importation of certain things. 2. The introduction into the Presidency of coffee plants and uncured berries from Ceylon, Mauritius, Réunion, Fiji, Southern India, Sumatra, Java, Natal and such other places as may be included in any proclamation under this Act is hereby prohibited.

Power to prohibit by proclamation importation of certain other things. 3.—(1) The Governor may from time to time, with the advice of the Executive Council, by proclamation, to be published in the *Gazette*, prohibit, either absolutely or conditionally, the importation into the Presidency or any part thereof of any plants, seeds, berries, earth, soil or other article or thing packed therewith or any goods, packages, coverings, or other articles or things which there shall be reason to believe to be affected with disease, or which may have come, either directly or indirectly, from any country or place named in such proclamation, or which, in his judgment, may be likely to communicate disease to plants.

(2) A copy of every such proclamation shall be suspended at the Treasury and in each Police Station of the Presidency.

(3) Any proclamation under this Act may be varied or revoked by the like authority.

Penalty. (4) Any person contravening Section Two of this Act or any proclamation published under the authority of this Act shall be liable, on summary conviction, to a penalty not exceeding twenty pounds.

Power to seize prohibited imports. 5. Every article or thing imported into this Presidency or any part thereof in contravention of this Act or of any proclamation under this Act may be seized by any treasury or revenue office, or by any member of the Leeward Islands Police Force, and shall be forfeited to Her Majesty and may be destroyed or otherwise dealt with as the Governor may direct.

Presumption of origin of imports of a prohibited kind. 6. Coffee plants and uncured berries and articles named in any proclamation in force under this Act, coming into the Presidency or any part thereof by sea, may be deemed to have come from a place the introduction thereof from which is prohibited by this Act and may be treated accordingly, unless the importer satisfies the Treasurer, or the principal treasury or revenue officer at the port of arrival, of the contrary.

CHARLES MAJOR,
Vice-President.

Passed the Legislative Council the 3rd June, 1897.

EDWARD B. JARVIS,
Acting Clerk.

Dated at Antigua the 4th day of June, 1897, in the sixtieth year of Her Majesty's Reign.

Duly published at Antigua the 5th day of June, 1897.

O. HUMPHREYS,
Provost Marshal

MONTSERRAT.

The Fumigation of Plants Ordinance, No. 1 of 1906, dated March 27, 1906, is identical with that of Antigua (5—1905), and in addition there is still in force No. 3 of 1897, dated April 20, 1897, which is also similar to the Antigua Law of that year.

This Ordinance, No. 3 of 1897, provides expressly (sec. 2) for the prohibition of the importation of coffee plants and uncured berries, and (sec. 3 [1]) for the prohibition either absolutely or conditionally of the importation into the Presidency of any plants, etc., which in the judgement of the Governor may be likely to communicate disease to plants.

ST. KITTS-NEVIS.

The Fumigation of Plants Ordinance, No. 3 of 1907, dated May 25, 1907, is identical with those in force in Dominica, Antigua and Montserrat, except in sections 4 and 14. In section 4 the word direction occurs instead of discretion, making the clause read: 'All plants imported into this Presidency together with the packages in which they are contained shall, subject to the direction of the Agricultural Authority, be fumigated.' In section 14, it is provided, among other things, that no person shall be liable to be punished twice for the same offence.

In St. Kitts, as in Montserrat, provision is made for the prohibition of all plants, etc., by an earlier Ordinance which is not repealed by the more recent one. St. Kitts Ordinance, No. 2 of 1897, dated April 24, 1897, is identical with the Montserrat Ordinance mentioned above. These two Ordinances were passed almost simultaneously, and make provision for exactly the same contingencies.

THE VIRGIN ISLANDS.

Ordinance No. 3 of 1897, dated June 10, 1897, is identical with the Ordinances quoted above—Montserrat, No. 3 of 1897, and St. Kitts-Nevis, No. 2 of 1897.

In this Presidency there is no provision for the fumigating or disinfecting of imported plants.

BERMUDA.

In Bermuda, legislation for the control of imported plants has been enacted (No. 14, 1899) with regulations (Jan. 12, 1901).

The Produce Inspection Act, No. 29, 1890, is entitled *An Act to provide for the Inspection of Potatos, Onions, and Tomatos, before exportation from these islands.* This Ordinance deals only with plants for export.

No. 14 of 1899, which prohibits the importation of bulbs, except under the regulations of the Board of Agriculture, is much more special in its application than the laws in other colonies, since it deals with only one

kind of plant. It provides for the cleaning, disinfection, purification and treatment of imported bulbs, but it does not state how these processes shall be carried out, nor what insecticide or other substance shall be used; but the Board of Agriculture is authorized to make the necessary regulations. The regulations, dated January 12, 1901, do not say by what means the treatment of the bulbs shall be carried out.

BERMUDA, No. 14—1899.

An Act for the protection of the Bulb Industry in these Islands.

[*5th September, 1899.*]

Whereas the cultivation of bulbs for exportation has become an important branch of industry in these Islands, and it is deemed necessary to take precautions against the importation and propagation of unsound, diseased or infected bulb stock;

We therefore, &c., be it enacted, &c:

Importation of bulbs prohibited except under regulations of Board of Agriculture.

1. The importation or landing in these islands of bulbs of every or any description other than such as the Board of Agriculture shall see fit to exempt from the restrictions of this Act, except under and subject to such safeguards and conditions as the Board of Agriculture shall from time to time prescribe under Regulations to be made under this Act for the prevention of the importation of diseased, infected, unsound or unhealthy bulbs, or such as are or may be suspected to be infected with injurious parasites or growths and of the packages and wrappings in which they are contained, and the covers soil and other materials in or with which they are packed, is hereby prohibited.

Board of Agriculture authorised to make regulations for the treatment and purification of imported bulb stock.

2. The Board of Agriculture is authorised to make and publish such Regulations for the inspection, examination removal and treatment before at or after importation or landing of bulbs to which this Act applies, and of the packages, wrappings and other things in or with which they are packed, and for the cleaning disinfection purification and treatment of such bulbs, or if necessary in the opinion of the Board, the destruction of any imported stock, before at or after the landing of the same, and from time to time revoke vary or alter such Regulations, and to take all such measures and precautions as may seem expedient to the Board for the prevention of the importation of any diseased or suspected bulbs, either generally or from any particular place or country mentioned in such Regulations, and to take all other ways and means to prevent the importation or propagation of unhealthy stock or of any bulbs in an unhealthy or foul condition, as to the Board shall seem necessary or expedient.

Importers of bulbs bound to carry out regulations.

3 Every importer or consignee of bulbs to which this Act applies shall be bound to carry into effect at his own expense and observe and obey the Regulations of the Board of Agriculture for the purification and treatment of such bulbs made and published under the provisions of this Act: and every such importer or consignee who shall offend against any Regulation made under this Act shall on conviction before any two Justices be liable to a penalty not exceeding twenty

pounds to be sued for and recovered with costs of prosecution by the Board of Agriculture or by any person authorised by the Board to prosecute for the same.

4. The Board of Agriculture or any member of the Board shall not be liable for any loss of or damage done to or sustained by any imported bulb stock subjected to any disinfecting or other process or treatment under any Regulation to be made under this Act: and all expenses attending the landing removal carriage transport and treatment of any bulbs treated under this Act or under the Regulations, shall be borne by and may be recovered from the owner or consignee of the bulbs by any person authorised by the Board to sue for the same. The Board not to be liable for any loss sustained by the treatment of bulbs under the provisions of this Act.

5. It shall be the duty of the respective Officers of the Revenue Department to carry into effect, and, as far as practicable, enforce the provisions of this Act, and to afford to the Board of Agriculture and its officers or servants every reasonable facility for carrying into effect the provisions of this Act and the Regulations of the Board of Agriculture. The Revenue Officers to be assistant in carrying out the Regulations of the Board.

6. The Receiver General shall be and he hereby is authorised and required to pay out of the Public Treasury to the order of the Board of Agriculture or any three members of the same, of whom the Chairman shall be one, any sums of money not exceeding three hundred pounds in any one year for carrying into execution the powers and duties of the Board under the provisions of this Act. Grant to Board of Agriculture for the purposes of this Act.

7. The expression in this Act 'bulbs to which this Act applies' shall mean all bulbs except such as are exempted from the provisions of this Act by the Board of Agriculture. Meaning of 'bulbs to which this Act applies.'

8. This Act may be cited as the Bulbs Act, 1899.

9. This Act shall continue in force until the thirty-first day of December One Thousand and Nine Hundred. Duration clause.

Regulations made on the 5th day of September, 1899, by the Board of Agriculture under the Bulbs Act, 1899, as amended by order of the Board of Agriculture. – 12 Jan. 1901.

1. The term 'Bulbs' in these Regulations includes Lily, Hyacinth and Narcissus bulbs.

2. Onions, Leeks, Eschalots, Garlic, and all Corns are exempted from the restrictions of this Act.

3. Owners or consignees of bulbs imported into these Islands shall notify in writing signed by the consignee the Superintendent of the Botanic Station as early as practicable of such consignments.

4. Consignments of bulbs will not be delivered without the authority of the Superintendent who will take and retain control of such consignments, for not less than 4 days for such inspection and treatment as may appear to him to be expedient. Amended.

5. The Superintendent may require such consignments to pass through the Public Garden for inspection and treatment. Amended.

6. The Superintendent is authorised to hire any conveyance or labour or make any such arrangement which, in his opinion, is necessary to convey any such consignments to the Public Garden.

7. After treatment the owner or consignee of any bulbs which have been treated is required to pay the expenses incurred and to remove the same within 48 hours, failing in which he will be chargeable for the storage of the bulbs at such rates as the Board shall sanction; and if the expenses are not paid and the bulbs removed within 4 days after notice to the owner or consignee to remove the same such bulbs may be destroyed or otherwise disposed of as the Board shall direct.

Substituted. 8. All bulbs which in the opinion of the Superintendent are diseased and which he thinks might be injurious to the Lily industry shall be destroyed.

Amended. 9. All bulbs brought into the Colony contrary to these Regulations may be seized and destroyed or otherwise dealt with.

10. Parcels of Bulbs by parcels post will not be delivered until after inspection, and if necessary treatment by the Superintendent and all expenses paid.

By order of the Board,

A. G. MONTAGU,
Clerk to the Board of Agriculture.

BAHAMAS.

In 1899, the Governor of the Bahamas, replying to the despatch of the Secretary of State for the Colonies, stated that there seemed to be no occasion for the passing of laws to provide for the prohibition or other control of imported plants on account of the very limited agricultural possibilities in those islands. The following is an extract:—

'The agricultural interests of this Colony must always be of a very limited character in view of the physical conformation of these islands, which are mainly composed of coral limestone rock, and it is only in very restricted areas that soil exists capable of any very extended agricultural operations. Cultivation, it may be said, is wholly confined to pine-apples, oranges and other species of the citrus family, and latterly the 'Agave' which produces the Sisal fibre, and it is very improbable that there will ever be any important additions to the economic products of this Colony. In regard to plant diseases, beyond the occurrence of what is popularly known as the 'Scale Insect' (probably a species of Aspidiotus) which attacks the orange trees, I am not aware that any trouble is experienced. Neither the pine-apple nor the Agave seems to be subject to disease which calls for special attention and any question of legislation on the lines suggested in your despatch would appear to be superfluous.'

The preceding pages give an account of the laws intended to deal with imported plants for the purpose of preventing the introduction of pests and diseases in all the British Colonies in Tropical America, so far as the writer has been able to learn of them.

It will be seen that in all the Colonies, except in the Bahamas and British Honduras, laws are in force to assist in protecting agricultural interests, by attempting to prevent the introduction of pests and diseases that might be transported through the medium of imported plants.

The provisions of the laws for this purpose fall under four heads: (1) total prohibition, (2) destruction of badly infested plants on arrival, (3) treatment of plants on arrival, to kill pests or diseases which may be known or suspected to be on them, and (4) inspection of suspected plants from time to time for a certain period, with power to destroy such plants if they are found within that time to be affected with any serious pest or disease.

The earlier laws, which are listed on page 198 of this paper, all come under the first head; they provide for the total prohibition of the importation of plants. Some of these are still in force, while others have been repealed. All these colonies, however, have laws by means of which total prohibition may be proclaimed against plants of certain kinds, from all places, all plants from certain places, or all plants from all places.

It may be well to mention that the term plant is intended to cover all plant-material, together with all packages, packing, etc. Thus all seeds, bulbs, roots, etc., if intended for propagation, are included, but fruits, vegetables, etc., intended to be used at once as food are not included.

No law is recorded as existing at British Honduras or in the Bahamas, and the law at Bermuda is designed only for the protection of the lily industry.

The other laws are general, Barbados making a definite pronouncement against seed-cotton for ginning, and cotton seed for planting and for the purpose of oil production. British Guiana, Trinidad, Grenada and St. Vincent make special mention of cacao by proclamation, while Dominica, also by proclamation, prohibits all plant importation from Dutch Guiana, and St. Lucia from South America.

Most of the laws quoted give the agricultural authority discretion in the matter of prescribing the treatment to be given to imported plants. This might also apply to the exemption from treatment of certain plants considered liable to be the means of introducing pests or diseases, such as tomato, cabbage and other vegetable seeds, and ordinary flower-garden seeds, sent out by reputable seedsmen in Europe or America. These are put up in sealed packets and are not likely to introduce any pest or disease which would seriously affect any of the crops in these islands. A problem still to be solved is that of treating plant material intended to be eaten, such as sweet potatos. The scarabee of the sweet potato (*Cryptoryhnchus batatae*) is found in most, if not all, of these islands, and there is little danger of serious damage resulting from its transporta-

tion from one to another, but it affords an example of the way in which an insect pest might be introduced in plant material intended to be eaten. Another sweet potato weevil (*Cylas formicarius*) is common in certain of the Southern States and in Jamaica. It has recently been reported as occurring in British Guiana. This insect sometimes occurs as a serious pest, and might easily be transported with the potatos to new localities. *Cylas formicarius* is stated to have been found in Barbados, but there is no evidence of its occurrence at the present time.

The power to provide for careful inspection, and then to destroy plants found to be infested with pests and diseases which are not likely to be controlled by any available means of disinfection, is very useful, and might prove a means of preventing the introduction of new or little known diseases, as well as those which are well known. Various borers would come under this head. Sweet potatos infested with the borer mentioned, and fruit infested by the fruit fly might also be included here.

The fruit fly (*Ceratitis capitata*) has been a serious pest in Bermuda, but legislation has been enacted, requiring the destruction of all fruit in the island for two seasons, and this pest has been brought under control. This was accomplished under the provisions of the Fruit Fly Destruction Act, 1907, which came into force on March 1, of that year.

In Trinidad and Grenada, in addition to the laws which deal with imported plants, laws are in force to provide for the control of pests and diseases within the island.

FUNGI CAUSING DISEASES OF CULTIVATED PLANTS IN THE WEST INDIES.

BY C. K. BANCROFT, B.A. (Cantab.).

GENERAL INTRODUCTION.

The scope of this paper is indicated by the author's introduction which states: 'In the following pages an attempt is made to give a brief descriptive account of those fungi which have from time to time been reported to be injurious to cultivated crops in the West Indies. The fungi are dealt with in the order of their systematic classification. Those who are desirous of obtaining further information respecting the life-histories of the parasites described can do so by consulting the literature quoted in connexion with the description of each species.'

Some of the fungi causing diseases of minor importance have not been included by Mr. Bancroft, probably owing to the fact that there is, as yet, no published record of their appearance in the West Indies. These omissions have been supplied in most cases by Mr. F. W. South, B.A., Mycologist to the Imperial Department of Agriculture, from the records kept at the Head Office of the Department, thus bringing forward information which was not accessible to Mr. Bancroft. These additions are marked with an asterisk.

A few fungi of minor importance have not been definitely identified, and consequently, have been omitted. With this exception, every effort has been made to render the account as complete as possible, and any omissions that may occur are due mainly to the absence of complete literature on the subject.

A note has been added containing a summary of the diseases probably caused by bacteria, a complete investigation of which, however, has not yet been undertaken.

All controversial matter has been avoided as far as possible, but an appendix by the Mycologist has been added, dealing very briefly with two points of which the importance could not be entirely disregarded. The first is an explanation of the attitude adopted toward the question of the relationship of *Trichosphaeria sacchari*, Massee, to *Thielaviopsis ethaceticus*, Went; and the second relates to the difficulties connected with the nomenclature of the fungi in the group Sphaerioidaceae, Phaeodidymeae, which embraces two important diseases of cacao and a disease of cocoa-nuts in the West Indies, in addition to an equally serious disease of *Castilloa elastica* and *Hevea brasiliensis* in the East.

PHYCOMYCETES.

PERONOSPORINEAE :—PERONOSPORACEAE.

Phytophthora omnivora, de Bary. (Black rot of Cacao Pods.) This disease is known in Ceylon as the 'Brown Pod' disease. Within recent years it has become much more general and destructive to cacao pods in Trinidad. The shell of the pod darkens first at one end, the darkening then spreading over its entire surface. The mycelium permeates and destroys the entire substance of the pericarp of the fruit and often attacks the seeds as well, the whole fruit thus becoming valueless. The conidial form of reproduction of the fungus appears on the surface of the pod as a white mould. Sexually produced oospores are formed in the diseased tissue of the pod and are liberated when the pod decays.

This fungus attacks many different plants, more especially in the seedling condition. It has also been reported to cause a disease of cultivated tomatos in England, and of various other plants throughout the world.

Diagnosis :—

Hyphae branched variously, haustoria absent; conidiophores slender, simple or sparingly unilaterally branched; conidia lemon-shaped, the size varying from 25 × 20 *Microns* to 60 × 40 *Microns*. Oospore globose, smooth, yellowish-brown, 20 – 30 *Microns* diam.

Hartig & Somerville. *Diseases of Trees*, p. 38.

Massee. *Kew Bulletin*, 1899.

Faber. *Die Krankheiten und Parasiten des Kakaobaumes*, p. 197.

Peronospora trichotoma, Massee. *Colocasia esculenta*, the tubers of which yield an important food, is known as 'eddoe' in Barbados, 'coco' in Jamaica and 'tania' in Trinidad. The fungus attacks the tubers of the plant. The disease was described by Mr. Massee in 1888, having been reported to have been doing damage to cocos in Jamaica in that year. The cut surface of the tuber has a number of bright yellow spots on it when the disease is in the incipient stages, these spots corresponding with the vascular bundles. The spots later become brown or blackish, and the intermediate portions of the tuber are tinged brown, showing that the mycelium has then spread to the ground-tissues between the vascular bundles. Entrance of the fungus is effected at a wounded surface where the skin of the tuber has become broken. Conidia are produced superficially, and oospores are formed in the decaying tissue.

Diagnosis :—

Mycelium thick; haustoria clavate; conidiophores fasciculate 2-3 times trichotomously divided; conidia small, obovate or subglobose 12 × 10 *Microns*; oospore globose; epispore brown with anastomising ridges, 35 – 40 *Microns* diam.

Massee. *Journ. Linn. Soc.*, XXIV, p. 45, 1888.

Peronospora cubensis, Berk & Curt. (Cucumber mildew.) A delicate, white mould occurs on the under surface of the leaves of many cucurbitaceous plants, and may sometimes prove to be very destructive if it is allowed to go on unchecked.

The disease has been recorded in the United States and in Japan; in addition to the cucumber it attacks the pumpkin, melon, squash, etc.

Massee. *Text-book Plant Dis.*, p. 80.

ASCOMYCETES.

Discomycetes.

Sclerotium sp. (Coffee Leaf Blight.) This disease of coffee has been reported to occur in Porto Rico. The fungus appears to attack the root system, first producing disease, and then ascends the stem by means of brown or black strands; when these strands reach a leaf they spread and form a cob-web-like structure. The leaf dies, but remains attached to the branch by the mycelium of the fungus. The fungus has been referred to the genus *Sclerotium*.

Porto Rico *Agric. Exp. Station Report*, 1904, p. 399.

Plectascineae :—Aspergillaceae.

Penicillium sp. (Black Heart or Core Rot of Pine-apple.) In 1901, pine-apples in Antigua were shown to be suffering from this disease. When a pine-apple is attacked it presents little external sign of disease; the fruit, as a rule, ripens unevenly, and segments or groups of segments here and there remain pale-green in colour. When a diseased fruit is cut open, black patches can be seen extending from near the outside towards the centre; these patches occur opposite to the pale-green spots on the surface. Later on, brown patches appear on the surface of the fruit and the surface becomes shrunken in places. A species of Penicillium occurs in the diseased fruitlets (eyes) and is thought to be the cause of the disease. In Queensland, where the 'Smooth Cayenne' variety suffers from the same disease, inoculation experiments have shown that the fungus can only effect an entrance into the fruit at a wounded surface, and the punctures produced by insects are considered to provide a point of entrance for the fungus. In the West Indies two insects commonly occur in the 'eyes'; these are a mealy bug (*Dactylopius* sp.) and a mite. It is, therefore, thought that these, by puncturing the pine-apple, afford a means of entrance for the fungus.

Stockdale. *West Ind. Bull.*, Vol. VIII., p. 161.

Meliola spp. (Sooty mould of Orange.) The leaves, and sometimes the fruit also, of the orange are frequently covered by a black incrustation, which constitutes the mycelium of a fungus belonging to the Aspergillaceae. The mycelium forms a compact membrane on the upper surface of the leaf, which frequently cracks and peels off in patches. The

fungus is not parasitic, but merely follows aphides and other insects which secrete 'honey-dew'. Injury is done to the trees by preventing the leaves from performing their proper functions; fruit covered by the fungus is also injured and is frequently rendered unsaleable. The black incrustations probably occur wherever the orange is cultivated, and are caused by different species of the genus *Meliola* in different countries.

Diagnosis of the genus *Meliola*:—

> Perithecia seated on superficial spots or effused patches of black, radiating mycelium, globose, mouthless, membranaceous, often surrounded by specialized appendages; asci usually short and broad, 2-8-spored; spores typically oblong, 2-5-septate, fuscous. Sometimes truly continuous and hyaline.
>
> Swingle & Webber. *U.S. Dept. Agric., Div. Veg., Path. and Physiol., Bull. 8.*
>
> Massee. *Journ. Bot.*, Vol. VI, p. 357.

Unicula spiralis, Berk. & Cooke.* This fungus causes the well-known powdery mildew of the grape vine, and has been found on grapes in Barbados.

PERISPORIALES :—PERISPORIACEAE.

Capnodium mangiferum,† Cooke & Broom. (Mango Black-Blight.) This is a black, incrusting, non-parasitic fungus which forms black patches on both sides of the leaf of the mango (*Mangifera indica*). The fungus spreads rapidly and forms a coating over the leaf-surface, thus interfering with the functions of the leaf: in this way great injury is frequently done to the trees. It seems probable that the fungus follows aphides, scales, and such insects as produce honey-dew.

Diagnosis:—

> Mycelium incrusted, effuse, sometimes almost covering the entire surface of the leaf, velvety, intensely black; perithecia globose-pyriform, rounded at top, mouth absent; asci obovoid, rounded at the apex 48 – 50 × 30 Microns: spores 8, 1-septate, hyaline, elliptical, slightly constricted at the septum, 12 – 15 × 5 – 6 Microns.
>
> Massee. *Text-book Plant Dis.*, p. 103.
>
> Cooke & Broom. *Grev.* IV, p. 47.

HYPOCREALES :—NECTRIEAE

Nectria Bainii, Massee. (Cacao Pod Disease.) This fungus was first reported to be doing damage to cacao pods in Trinidad in 1898. Semicircular blotches make their appearance on the pod, and the diseased parts become soft and watery. Later on, they become covered with a yellow or

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† The question of nomenclature connected with the genera *Meliola* and *Capnodium* is complicated. Some authors have expressed the opinion that fungi described as species of *Capnodium* are identical with certain species of *Meliola*. [F.W.S.]

orange-coloured mycelium which is studded with minute, bright-red perithecia. The perithecia are often preceded by a small Fusarium-like mould, whitish in appearance; the connexion between these stages has not yet been established.

Diagnosis :—

Perithecia gregarious, beset by a yellow or orange mycelium, spherical, red, 300 – 350 Microns diam.; asci cylindrical, clavate, shortly stalked, 8-spored, 80 – 90 × 7-9 Microns, spores elliptic-oblong, subacute at both ends, uniseptate hyaline 10 – 12 × 5 Microns.

Massee. *Kew Bulletin*, 1899, p. 1.

Hart. *West Ind. Bull.*, Vol. I, p. 422.

F. von Faber. *Die Krankheiten und Parasiten des Kakaobaumes*, p. 216.

Nectria theobromae, Massee. (Canker Disease of Cacao.) This disease was investigated by Howard, from Grenada, in 1901. It has since been met with in Trinidad, Dominica, St. Lucia and St. Vincent. The fungus attacks the stem of the cacao tree, the first recognizable symptom being the production of a red, gummy liquid which oozes out from the bark. The bark, when cut, is found to be red, and the discoloration extends as far inwards as the young wood. The path by which the diseased area spreads varies; it may be a narrow band and may ring the tree, in which case death soon results; or it may spread in different directions without encircling the tree, in which case death is slower. The branches above the diseased area die, those just above that area dying first. In the early stages of the disease two conidial forms make their appearance; one is a form of Fusarium-like conidia, which are budded off from short hyphae, and the others are unicellular conidia. The perithecia are produced later and are red in colour. These can be found most frequently during the rainy season.

Calonectria flavida, Massee, may occur along with *Nectria theobromae*, or without it. The perithecia are yellow and produce 3-septate ascospores.

The connexion between the conidial and ascigerous forms has not yet been established.

Fusarium conidia 5 - 7-septate, 50 – 80 × 4·5 – 8·5 Microns.
Unicellular conidia elliptical 6·6 – 11 × 4·4 Microns.
Calonectria ascospores 22 × 9 Microns.

Howard. *West Ind. Bull.*, Vol. II, p. 200.

Stockdale. *West Ind. Bull.*, Vol. IX, p. 171.

Nectria ipomoeae,* Hals. The sweet potato (*Ipomoea Batatas*) and the egg-plant (*Solanum Melongena*) are attacked by this fungus.

The stems wither and are covered with a white mould which is the fusarium condition of the fungus. Later on, clusters of flesh-coloured perithecia appear on the diseased

*The *Tubercularia* stage of a species of *Nectria* has also been observed on pigeon peas in Trinidad (*Trinidad Bull.*, Vol. IV, p. 313.)—[*F. W. S.*]

stems. The disease shows itself first near the ground-line and then spreads to the stem and root.

Diagnosis :—

Perithecia in little clusters, conico-globose, papillate, red; asci cylindric-clavate, 8-spored; spores hyaline, cylindric-oblong, 1-septate, slightly constricted at the septum.

Halsted. *Rep. N. Jersey, Agric. Expt. St.*, 1891, p. 281.

Massee. *Text-book Plant Dis.*, p. 132.

Calonectria gigaspora, Massee. This species is described from Trinidad as occurring in the channel produced by the moth borer in the stem of the sugar-cane.

Diagnosis :—

Perithecia aggregated, obovate, glabrous, scarlet, 1 mm. high; asci very long, 8-spored, paraphyses absent; spores hyaline, fusoid, at length 3-septate, 90 – 100 × 20 *Microns*.

Hart. *Trinidad Bull.*, 1901, p. 335.
Massee. *Kew Bulletin*, 1906.

Sphaerostilbe flavidum, Massee. (Coffee Disease, of the New World.) This disease is known as 'spot' or 'small pox' in allusion to the spotted appearance of the leaves, young shoots and fruits of infected trees. It has been reported to occur in Guatemala, New Granada, Costa Rica, Venezuela, Nicaragua, Dutch Guiana and Brazil,† but there is not yet any account of its occurrence in the West Indies.

On infected leaves scattered, circular, whitish patches are formed, equally evident on both sides of the leaf. These leaves become yellowish and fall, in some cases complete defoliation of the plants resulting. On the shoots the spots are whitish and more or less elongated. The fruit of the fungus appears on the spots as small, yellowish, pin-like structures from 1·5 to 2 mm. high. The free tip of each hypha swells and becomes subglobose, and from this spring slender, simple or sparingly branched conidiophores, each of which bears a single subglobose conidium at its apex. The conidia are hyaline and 2·5 *Microns* in diameter. This condition is known as *Stilbum flavidum* or *Stilbella flavida*. This fungus has recently been shown to be the conidial form of Sphaerostilbe, an ascigerous genus. All attempts to infect coffee plants with the conidia of *Stilbum flavidum* have failed; the conidial stage of the fungus may, therefore, be concluded to be effete. The ascigerous stage is developed on the whitish patches of the stem and fruit, but not on the leaves. The fungus must, therefore, be reproduced by ascospores only.

Diagnosis :—

Perithecia ovate, densely massed into suborbicular irregular patches, slightly reddish, verrucose, with a slightly prominent papillate ostiole. Asci cylindrical,

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†The fungus has also been found very recently in Dominica. (*Agric. News*, Vol. VIII, p. 292). [F.W.S.]

abruptly truncate above, 8-spored. Spores hyaline, ellipsoidal pointed at both ends, unseptate 15 × 6 – 7 *Microns.*

Massee. *Text-book Plant Dis.*, p. 445.

Massee. *Kew Bulletin*, 1909, p. 337.

SPHAERIALES :—SPHAERIACEAE.

Rosellinia Hartii, Massee.* This fungus has been found occasionally on cacao and also on *Ficus indica* in Trinidad ; it is apparently destructive but not common.

Hart. *West Ind. Com. Circular*, Vol. XXIV, p. 511.

Trichosphaeria sacchari, Massee. (Rind Fungus of Sugar-cane.) This disease for a time almost paralysed the sugar industry in Barbados and other West Indian Islands ; it has also been reported from Mauritius, India, Java and Queensland. Attention was first called to the fungus in Trinidad, in the year 1893. The fungus gains access to the interior of the sugar-cane at a wounded surface, such as through the broken ends of lateral shoots, leaf-bases, etc., but more especially through wounds made by the moth-borer insect (*Diatraea saccharalis*), and possibly sometimes by the shot borer (*Xyleborus perforans*). In the interior of the cane the fungus first follows the course of the vascular bundles producing bright-red, longitudinal streaks ; the hyphae then attack the fundamental tissue, entering the cells by the pits in the cell-walls. Three distinct means of propagation have been attributed to this fungus :—

(1) The Melanconium stage.

The spores ooze out from the surface of the cane in the form of black, curved tendrils. The conidia are formed in conceptacles produced under the epidermis. Conidia unicellular, pale-brown, cylindrical, straight or slightly curved, 14 – 15 × 3·5 – 4 *Microns.* The conidia generally form two germ-tubes and give rise on germination to the second stage of the fungus.

(2) The Macroconidial stage.

This forms an intense, black, velvety layer lining cracks and crevices in decaying canes. The conidia are produced in chains originating within the ruptured apex of a hypha ; the terminal conidium is globose, 20 – 25 *Microns*, the others barrel-shaped, 18 – 20 × 12 *Microns*, blackish-brown. The microconidial stage is similar in origin and structure to the macroconidial, growing on the diseased surface of the cane and forming black, velvety patches. The microconidial form is a modification of the macro-form, developing from the same hyphae and probably owing its peculiarities to light, exposure, etc

(3) Ascigerous stage.

The perithecia are produced by the mycelium which bears microconidia; they occur on dead or more or less decayed canes. Perithecia broadly ovate, blackish-brown, sparsely clothed with long, dark, rigid hairs; asci cylindrical; spores eight, hyaline, continuous, elliptic-oblong, 8 - 9 × 4 Microns; paraphyses absent.

The melanconium stage is the form destined for rapid reproduction and can reproduce itself continually without the intervention of any other spore-form.

Recent work on the raising of resistant varieties of sugar-cane has met with a good measure of success.

Massee. *Ann. Bot.*, 1893, p. 515.

Howard. *Ann. Bot.*, XIV, p. 617 (1900).

„ „ „ XVII, p. 373 (1903).

(Pine-apple Disease.) Pine-apples that have been packed for shipping or storing frequently show signs of fungous disease. The commonest fungus present is *Trichosphaeria sacchari*, the rind fungus of the sugar-cane.

Diseased pines are soft and watery in patches, and a distinct odour of ethyl acetate is emitted from these diseased areas. The fungus can only effect an entrance at a wound, i.e., at bruises on the fruit, produced in picking, or at the cut end of the fruit-stalk.

Stockdale. *West Ind. Bull.*, Vol. VIII, p. 163.

PLEOSPORACEAE.

Leptosphaeria sacchari, Breda de Haan. (Ring-spot of Sugar-cane.) Occurs in the West Indies, Java and India. The disease commences in the form of small, purplish spots on the leaf surface; these spots increase in size, and as they expand, dry up in the centre. Each spot takes the form of a ring consisting of a purple or brownish band, outside which is a yellow area of the leaf. Finally, the spots become large and elongated and frequently run together.

On the surface, the hyphae produce curved, usually 3-4-septate spores; these have been shown by Breda de Haan to be capable of infecting healthy leaves. Later on, a second spore-form appears in the form of black dots on the upper surface of the leaf; the dots are arranged in rows and are visible to the naked eye.

Diagnosis :—

Perithecia 140 Microns diam.; ascospores 3-septate, 20 - 24 x 5 Microns, brownish.

Butler. *Memoirs of Dept. Agric. in India*, Vol. I, No. 3.

Wakker & Went. *De Zietken van het Suikerriet op Java*, p. 149.

VALSACEAE.

Eutypa erumpens, Massee.* This fungus is reported as causing the death of several trees including cacao, nutmeg,

Barbados evergreen (*Ficus* sp.) and many forest trees. It occurs in Trinidad, Barbados and Grenada. The fungus is probably a wound parasite. It forms irregular black patches on the bark, varying in size from one-half to two or more inches in diameter. These patches have a dull rough surface, and the perithecia of the fungus are sunken in them, so that only the short, beak-shaped ostioles project. The asci are club-shaped, 8-spored and borne on long stalks. The spores are unicellular and transparent.

Bull. Agric. Inform., Trinidad. 1909. No. 61.

BASIDIOMYCETES.

HYMENOMYCETINEAE :—AGARICACEAE.

Marasmius equicrinis, Müller. (Horse-hair Blight of Cacao.) This appears like a tuft of horse hair caught in the twigs of the tree. Some of the threads are closely attached to the bark, and the mycelium resembles that of the thread-blight in some respects.

Diagnosis :—

White to yellowish, pileus membranaceous, convex, obtuse, 1 – 2 mm. broad : stalk 1 cm. or more long, bristly, rigid, black, shining, rising from the black, horse-hair-like mycelium ; lamellae few, separated, paler than the pileus.

Stockdale, *West Ind. Bull.*, Vol. IX, p. 179.

Cooke. *Grev.* VIII.

Saccardo. *Syll.* V, p. 553.

Lewton-Brain. *West Ind. Bull.*, Vol. VI, p. 87.

Marasmius sacchari, Wakker. (Root Disease of Sugar-cane.) This disease has caused great loss to sugar-cane growers in the West Indies, and was especially prominent in Barbados in 1904. The affected plants show symptoms resembling those produced by a deficient water-supply. The leaves become dry and withered; fewer leaves are produced, and the lower leaves, which normally fall away from the stem and form 'trash' on the ground, remain attached. The stools are dwarfed and but loosely fixed in the soil, so as to be easily uprooted. The fungus attacks the roots; the younger roots are short and red at their tips. The proper absorption of water and nutrient salts by the plant is thus checked, and the parts above ground, in consequence, show the symptoms here described. The lowest leaf-sheaths can be seen to be matted together by a white mycelium. The fructifications of the fungus appear as toad-stools at the base of the attached stools; they are white, delicate structures.

Diagnosis :—

Gregarious or fasiculate at the base, variable, flesh membranaceous, persistent; pileus white, broadly campanulate, then dingy-white and plane or cup-shaped, 15 mm. diam.; gills white, simple or bifurcate; stem central,

white, 15 mm. long, apex tubiform, base villous, hyphae white; spores hyaline, continuous, irregularly oblong, ends attenuated, rounded, 16-20 × 4-5 Microns.

Lewton-Brain. *West Ind. Bull.*, Vol. VI, p. 34.

Wakker. *De Zietken van het Suikerriet op Java*, p. 194.

Marasmius hawaiiensis, Cobb, is reported to cause a root disease of sugar-cane in Hawaii, and is considered to be a different species from *M. sacchari*.

Cobb. *Hawiian Sugar Planters' Assocn. Report*, No. 6.

Marasmius plicatus is reported to cause a root disease of sugar-cane in Louisiana.

Marasmius sp. probably causes root disease of sweet potato, and possibly also of Guinea corn, Imphee, and Indian corn.

Marasmius semiustus, Berk. & Curt. (Banana Disease.) Certain of the banana trees in Trinidad and other of the West Indian Islands have been reported to be affected by this fungus. The mycelium permeates the tissues of the banana 'stem' and attacks the inflorescence as it is growing up the centre of the leaf-sheaths which form the so-called 'stem'. On the surface of the 'stem' can be seen the fructifications of the fungus frequently growing in immense numbers. Numbers of minute, whitish sclerotia occur in the diseased tissues.

Pileus ½-1 inch across, thin, yellowish-brown; gills wide apart, thin and dirty white; stem ½-¾ inch long, thin with a flattened foot of attachment.

Diagnosis :—

White, becoming rufous when dry; pileus eccentric, convex, then plane, glabrous: gills approaching the stem, connected by wrinkles; stem compressed, glabrous, 2-3 mm. diam. The fungus was first described from Cuba in 1867.

Journ. Linn. Soc., 1869, Vol. X.

Massee. *Text-book Plant Dis.*, p. 387.

Schizophyllum commune, Fries. (Sugar-cane Agaric.) This fungus is said to be a parasite on the stems of cultivated sugar-cane in the West Indies. It has also been recorded to be parasitic on the mulberry tree by Prillieux. It is however more frequently saprophytic.

Diagnosis :—

Pileus fan-shaped, very thin, white or grey, downy, often lobed, 1–2 inches broad; gills pale-brown with a purple tinge, split portions of the edge of the gills revolute; spores dingy, 4 – 6 × 2 – 3 Microns.

Massee. *Text-book Plant Dis.*, p. 207.

Prillieux & Delacroix. *Bull. du Min. de l' Agric.*, No. 5, Sept. 1893.

POLYPORACEAE.

Polystictus hirsutus Fr.* This fungus is probably a partial parasite, and has been found on limes in Dominica.

THELEPHORACEAE.

Corticium lilaco-fuscum, Berk. & Curt. (Pink Disease of Cacao.) The disease, though reported to occur in Dominica and St. Lucia, does not seem to be of a serious nature. Pinkish incrustations appear on the branches of the tree; these are composed of closely packed, adpressed, fungal hyphae. The hyphae may penetrate the bark and extend as far as the young wood. When the branches are thus affected, the bark cracks and peels off. The fungus itself seems to do little damage, since the bark is easily renewed; but it forms places of entrance for wound fungi, notably the cacao canker fungus.

Diagnosis of genus *Corticium*:—

> Hymenophore broadly effuse, entirely adnate to substratum; hymenium smooth, waxy, consisting of basidia and paraphyses only, springing directly from the mycelium; spores continuous, hyaline; basidia typically tetrasporous. Petch suggests that this may be identical with *Corticium javanicum*, which attacks *Hevea brasiliensis*, tea and other plants in Ceylon, Java, etc.

Stockdale. *West Ind. Bull.*, Vol. IX, p. 178.
Petch. *Agric. Journ. Royal Bot. Gdns., Ceylon*, Vol. IV, 1909.

(Unidentified.) Thread-blights of cacao have been reported to occur in Trinidad and in St. Lucia.

The mycelium of the fungus takes the form of threads which are closely adpressed to the bark of the tree. These threads run along the twigs and branches and, when young, are thin and white, but darken and thicken as they grow older. The buds are covered by a white felt caused by the branching and expansion of the threads, and the under surfaces of the leaves are also frequently covered.

The hyphae composing the thread give off strands which grow into crevices in the bark on the older parts of the tree; on the young twigs, however, they penetrate the outer tissues and pass to the cortex, where they branch profusely. These hyphae may even pass to the wood of the young twigs, but the cortex appears to be the part which is materially injured.

Careful comparison of mycelia from different trees indicates that the 'thread-blight' is in all probability due to different fungi, in different localities.

'Thread-blight' occurs in India where, in addition to attacking the tea plant, it is known to be present on many wild trees.

The 'thread-blight' fungus of the tea plant is *Stilbum nanum*. Some of the fungi attacking the cacao tree are said to be Basidiomycetes, as clamp connexions have been observed in their mycelia, but they have not yet been identified.

Lewton-Brain. *West Ind. Bull.*, Vol. VI, p. 87.
Tropical Agriculturist, No. 25, 1905.
Stockdale. *West Ind. Bull.*, Vol. IX, p. 179.

(Unidentified.) (Root Disease of Cacao.)* In the islands of Dominica, St. Lucia and Grenada, cacao is often killed by a fungus which causes a disease of the roots. The disease usually spreads outwards in a circle from the tree first attacked and, if not attended to, may cause the death of a large number of trees. The branches are seen to wither from the tips, the leaves wilt and fall, the branches die, and subsequently, the whole tree may be killed. The fungus often starts by attacking the roots of trees which have been used for shade or as wind-belts, as for example, Pois-doux, bread-fruit, bread-nut, mango, pomme rose, and avocado pear. When the diseased roots are laid bare, they are found to be black and decayed, and white strands of mycelium are observed to be attached to them, which pass into the tissues of the roots. If the bark is peeled off, a white web of mycelium, arranged in somewhat star-like masses, can be seen between the bark and the wood. The mycelium is at first white, then grey, and finally brown. Clamp connexions have been occasionally observed in the mycelium, and recently a Basidiomycetous fructification has been discovered, which may prove to be that of the root disease. A similar disease attacks nutmegs in Grenada, and cacao and coffee in Jamaica.

Stockdale. *West Ind. Bull.*, Vol. IX, p. 179.

UREDINALES.

Uredo arachidis, Lagh. (Ground nut Rust.) The leaves of the ground nut, or pea nut, are sometimes affected with this disease. The fungus was formerly described from Surinam, and has recently made its appearance in Dominica. Small, brownish spots appear on the under surface of attacked leaves.

Diagnosis :—

Sori small, on under side, scattered, surrounded by the ruptured epidermis, brown: uredospore ovoid-round, 24 – 30 *Microns* in diameter, epispore yellow.

Saccardo. *Syll.*, XIV, p. 394.

Uredo cannae, Winter. (Canna Rust.) The disease was first described from Brazil; more recently it has made its appearance in Trinidad, where it has proved to be a destructive pest to cultivated cannas. Small, orange-coloured spots are formed on the leaves, which become discoloured and die.

Diagnosis :—

Sori generally hypophyllous, rarely also epiphyllous, without spots, either densely scattered over the entire surface or collected in groups, minute, pale-yellow, for a long time covered by the epidermis; spores variable in form, yellowish, echinulate, 25 – 45 x 16 – 23 *Microns*.

Trinidad Bull., Vol. III, p. 86.
Massee. *Text-book Plant Dis.*, p. 423.

Uredo gossypii, Lager. (Cotton Rust.) All green parts of the cotton plant seem to be affected by this fungus. It was first recorded in South America and has since been noticed in the West Indies. It has recently caused considerable damage to cotton in the United States of America. In the West Indies the disease hitherto does not seem to be dangerous.

On the upper surface of the leaf, small brown spots occur; they are roundish or angular in shape. The spores are produced in clusters mainly on the under side of the leaf; they break through the epidermis in the form of pustules.

Diagnosis:—

Sori formed below the epidermis, then bursting forth spores ovoid or pyriform 24-30 x 15-18 Microns; epispore equally thickened, pale-yellow, echinulate, paraphyses clavate.

Lagerheim. *Journ. Myc.*, Vol. VII, p. 48.
Lewton-Brain. *West Ind. Bull.*, Vol. VI, p. 117.

USTILAGINEAE.

Ustilago sacchari, Rabenh. (Sugar-cane Brand.) In Java this fungus has been reported to do serious damage to the sugar-cane. Mr. O. W. Barrett observed it in Trinidad where, however, it appeared to be limited to one or two plantations, and the extent of the damage done seemed to be of a less serious nature.

The leaves are the parts affected, and more especially the younger ones which have not yet separated from each other. The whole of these upper leaves is converted into a discoloured, projecting structure.

Diagnosis:—

Spore-mass black; spores globose or angularly globose, 8-18 Microns diam., olive-brown or rufous; epispore thick smooth.

Barrett. *Proc. Agric. Soc. of Trinidad and Tobago*, No. 252.
Wakker & Went. *De Ziekten van het Suikerriet op Java*, p. 24.

Graphiola phoenicis, Pait. (Date Palm Disease.) The fungus forms small, black spots on both sides of the leaves of the date palm (*Phoenix dactylifera*). The internal tissues of the leaves are in many cases much damaged.

Ann. Scienc. Nat. Botanique, 1824, p. 473.

FUNGI IMPERFECTI.

SPHAEROPSIDALES:—SPHAERIOIDACEAE.

Botryodiplodia sp. (Root Disease of Cocoa-nut) The leaves first show signs of the disease; they become wilted and yellow at their tips. Finally they dry up, blacken and hang down.

Shedding of the affected leaves results; the leaf-base frequently remains attached to the tree, however. The nuts are shed in all stages, irrespective of size. The stem has a sour-smelling, red discoloration commencing at the level of the ground and extending upwards.

The roots, when examined microscopically, are seen to contain a mycelium composed of dark-coloured, septate hyphae, which run between and through the cells. All the tissues of the root appear to be attacked, including the xylem vessels. The disease seems to be but little investigated; it has been recorded to occur in Trinidad and British Guiana.

Stockdale. *West Ind. Bull.*, Vol. IX, p. 363.

Botryodiplodia diplocarpa, E & E.* Is reported as probably causing diseases of citrus trees in Trinidad. The fructifications of the fungus appear as black pustules under the bark.

Diplodia cacaoicola, P. Henn. (Die-back of Cacao, also Brown Rot of Cacao Pods.) This disease is known to occur in Dominica, St. Lucia and Grenada. The fungus causes considerable damage to cacao pods; a circular, brown patch appears on the pod and then extends over its surface. The rind and contents of the pod are completely destroyed. In many cases the brown patches appear at one or other end of the pod, but sometimes they may occur elsewhere, especially where the pod has been injured. The beans soon become attacked, and are rendered useless. At about the centre of the brown patch, small circular elevations occur; these are pycnidia, and are filled with a greyish-white dust, which after becomes dark-coloured. The fungus also attacks the branches of the tree.

On the stem of the sugar-cane, dark bodies sometimes make their appearance in the form of vertical lines; these bodies by their growth eventually rupture the rind of the cane. This is due to the formation of colonies of pycnidia under the rind, which later on become erumpent; the dark colour being caused by the presence of a dark-brown septate mycelium. Howard has carefully investigated the fungus and finds it to be identical with *Diplodia cacaoicola*, the 'die-back' fungus on cacao. This investigator was able to show that the fungus on cacao could be transferred to the sugar-cane and vice versa, so that on neither plant had the fungus become sufficiently closely adapted to the host to form a biological species.

Howard. *West Ind. Bull.*, Vol. II, p. 203.
F. C. von Faber. *Die Krankheiten und Parasiten des Kakaobaumes*, p. 28.

Diagnosis :—

Pycnidia scattered, in the cortex, innate, black; spores ellipsoid-oblong or sub-ovoid, 1-septate in the middle, hardly constricted, obtuse on both sides; loculi 1-guttulate, sooty black. Spores 22 - 18 x 12-14 Microns.

Botryodiplodia theobromae, Pat.,* has been described as occurring on cacao pods from Ecuador. The genera *Botryodiplodia* and *Diplodia* are distinguished from each other by the former possessing pycnidia in colonies produced on a stroma. Howard observes that, in the case of the West Indian fungus, there is a good deal of variation in the arrangement of the pycnidia and of the hyphae surrounding them, and he suggests that these two forms may be identical.

Howard. *Ann. Bot.*, XV, p. 683, pl. XXVII.
Engler & Prantl. *Die Nat. Pflanzenfam.* Fungi I, Teil I, *Abteilung*, p. 372.

Diplodia epicocos, Cooke. This was described as being parasitic on cocoa-nut in India; the disease also occurs in Trinidad. The fungus attacks the leaves of the tree.

Diagnosis:—

Pycnidia scattered or almost gregarious, at length superficial or semi-immersed, globose, black; spores elliptical 1-septate, constricted, brown, 22 x 10 – 12 Microns.

Cooke. *Grev.*, t 87, Fig 2.
Saccardo. *Syll.*, Vol. III, p. 372.

Diplodia sp. (A Pine-apple Disease.) This fungus, like *Trichosphaeria sacchari*, has been found to attack ripe pine-apples. It appears to effect an entrance at the cut end of the fruit-stalk, whence it passes up the central vascular core of the fruit and spreads to the surrounding pulp. The pulp of fruits which are attacked becomes soft and watery; but the odour of ethyl acetate produced in the case of the *Trichosphaeria sacchari* disease does not occur. The older diseased parts become black; this is due to the dark colour of the mycelium of the fungus. The pycnidia containing the spores by which the fungus reproduces itself occur as black dots under the rind.

Stockdale. *West Ind. Bull.*, Vol. VIII, p. 163.

Lasiodiplodia sp. is described by Mr. O. W. Barrett from Trinidad as being responsible for the greater amount of the damage done to cacao pods by fungus disease. The fungus infects the fruits and the cushions from which the fruit-stalks arise. The infected area on the pod is of a dull-brown colour. The mycelium of the fungus spreads from the shell of the pod to the pulp around the seeds, and then attacks the seeds themselves. Infection appears to start at the distal extremity of the pod more often than at the base.

[The same fungus or an allied species was found in Trinidad, Grenada and Dominica on pods of cacao by Mr. F. A. Stockdale, and also on the stems, branches and cushions. It frequently follows areas that had been previously affected with canker.

The fungus was shown by infection experiments to be a weak wound parasite, and its spread, as observed in Dominica, was probably slow, though the trees eventually died. In Trinidad, however, it is said to spread very fast in the tissues and to kill the trees very rapidly.

Stockdale. *West Ind. Bull.*, Vol. IX, p. 177. (F. W. S.)]

This disease has been reported to occur in San Domingo. The fungus in this case is thought to be *Lasiodiplodia tubericola*, but the species has not yet been identified with certainty. The fungus is also known to cause a disease of mango fruits in San Domingo.

Charles. *Journ. Myc.*, XII, 1906.
Barrett. *Agric. Soc. Proc., Trinidad and Tobago*, No. 280.

MELANCONIALES :—MELANCONIACEAE.

Gloeosporium ampelophagum, Sacc.* This fungus is the cause of Grape Rot and is common in Europe and America. It has been reported as occurring in St. Lucia.

Massee. *Text-book Plant Dis.*, p. 278.

Gloeosporium musarum, Cooke & Massee. (Banana Anthracnose.) A disease of ripe bananas was described from Brisbane as being caused by this fungus, and has since been recorded in the United States of America; there is no account of its occurrence in the West Indies, and a brief reference to it will, therefore, suffice. Black spots occur on the fruit and these gradually spread over its entire surface causing rotting to take place. When the spores of the fungus are extruded, a roseate tint is imparted to the spots.

Stoneman. *Bot. Gaz.*, Vol. XXVI, p. 69.
Massee. *Text-book Plant Dis.*, p. 287.

Colletotrichum Agaves, Cav.* This fungus causes a disease of the leaves of various species of Agave and is reported as occurring in Antigua. Spots are formed on the leaves which are darker in colour than the adjacent parts, and eventually turn brown or grey. The plants attacked finally die unless steps are taken to prevent the spread of the disease.

The spore-bearing pustules of the fungus appear on the diseased areas and occur as orange spots, frequently arranged in concentric rings. The fungus makes its entrance through the stomata or by means of wounds.

Diagnosis :—

Spots circular or elliptical, often becoming confluent, olive, changing to grey or brown; acervuli spherical to oblong, usually breaking through the epidermis of the host in concentric rings and ejecting orange-coloured masses of conidia; setae acute to blunt, light-brown, 3-5-septate, 110 to 170 Microns by 5-6 Microns; conidia oblong to cylindrical, hyaline, with one to two guttules, 16-31 x 5-6 Microns; conidiophores erect hyaline, usually simple, 6-7 Microns in diam., but very variable in length in different acervuli.

G. G. Hedgcock. *Sixteenth Ann. Rep., Missouri Bot. Gdn*, p. 153.

Colletotrichum Cradwickii, Bancroft. This fungus has recently been found on cacao pods from Jamaica and is considered to be a new species. The shell of the pods affected with the fungus were found to be quite hard. Yellow masses appear on the surface of the pod; these consist of conidiophores and setae, and become later pinkish in colour.

Diagnosis:—

Conidiophores hyaline, length at least greater than that of a spore; spores hyaline, pinkish in mass, elongated, with a slight constriction at the middle, without a central refringent portion, 14 – 17 x 5 *Microns*; setae straight, rigid, tapering, pointed, 2 - 3 times septate, purple, 70 – 100 *Microns* long by 4 – 5 *Microns* broad, on the average.

This species is distinguished from other species of *Colletotrichum* by the characters of the setae.

Five other species of *Colletotrichum* occur on cacao pods and may be mentioned here:—

Colletotrichum luxificum, van Hall and Drost.
„ *theobromae*, Apell and Stunk.
„ *theobromicolum*, Delacroix.
„ *brachytrichum*, Delacroix.
„ *incarnatum*, Zimmermann.

Colletotrichum falcatum, Went. (Red Rot of Sugarcane.) This disease has been reported from Hawaii, West Indies, Bengal, Madras, Java and Queensland. When a cane is attacked, the upper leaves lose colour and begin to drop; the third or fourth leaves from the unopened bud are usually first affected in this way. The leaf commences to wither at the tip and the withering extends down the margins; later on, the whole crown of leaves withers and drops. So that, as far as these primary symptoms are concerned, the cane appears to be suffering from excessive drought; if, however, the cane be split open, it can be seen to be reddened at one or two of the lower internodes. The discoloration appears as red dots or streaks in the vascular bundles; these extend so as to form blotches, and finally the interior of the cane becomes much reddened. Each red blotch has usually a white centre composed of dead cells. The reddening extends down into the stool and also towards the top of the cane. The cane becomes light and loses much of its juice; finally it turns dark in colour and the inside becomes deep-brown and crumbly. When one cane of a stool is affected, destruction of the whole stool usually follows. Infection appears to take place from below, i.e. either from the soil, or from the parent 'cutting'.

In some cases, the nodes in the middle of the cane may be the first to become infected; this differs from the above description in the point of attack. Again, the fungus may attack the roots of the cane or may also occur on the leaves.

The spores are produced on the surface of the cane at the nodes, or in sunken areas in the internodes. The fungus does not appear to produce spores abundantly. The conidiophores arise from a stroma, along with setae.

Diagnosis :—

Setae sometimes seriate, sometimes in a pseudo-conceptacle, dagger-shaped, 109 - 209 x 4 Microns, brown ; conidia sickle-shaped, 25 x 4 Microns, hyaline ; conidiophores ovoid, 20 x 8 Microns, hyaline or fuscous.

Went. *Mededeelingen van het Proefstation*, West Java, 1893.

Butler. *Memoirs Agric. Dept. in India*, Vol. I, No. 3.

Massee. 'Root Disease of Sugar-cane', *Kew Bulletin* No. 48, 1893.

Wakker & Went. *De Ziekten van het Suikerriet op Java*, p. 36.

Colletotrichum glœosporioides, Penzig.* (Wither Tip.) Spotting of the leaves and anthracnose of the fruit of various citrus trees are all due to this fungus. It occurs commonly in various parts of America, and has been found in Cuba and Jamaica.

The young leaves and shoots, when severely attacked, curl and dry up, and the fruit shows sunken, hard, brownish areas. The diseased areas on the leaves have a very definite margin, but on the fruit this is not so well marked. The spore-bearing pustules appear as small black dots arranged in concentric rings on the diseased surfaces. They are most numerous on the fruit, where they may even blacken the diseased surface almost completely. These pustules produce masses of minute, hyaline, cylindrical spores, which are rounded at both ends and contain two or more oil drops.

Diagnosis :—

Spots on the leaves amphigenous, pallid or greyish, with a definite, narrow, yellowish-brown border, mostly marginal, 1-4 cm. across, or extending along the entire margin of the leaf; acervuli amphigenous, black, subglobose, closely aggregated, sometimes confluent, covered by the cuticle, which is soon torn ; 175-240 Microns in diam. : spores hyaline, oblong or cylindrical, mostly with two or three oil drops 16 - 18 × 4-6 Microns.

Hume. 'Anthracnose of the Pomelo', *Bull. No. 74, Florida Agric. Exp. Station.*

Rolfs. *Bull. 52, Bureau of Plant Industry*, U. S. D. A.

Colletotrichum gossypii, Southw. (Cotton Anthracnose.) The fruits, stem and leaves of the cotton plant are attacked by this fungus, but the most serious damage is done when it affects the fruits ; a loss of as much as 50 per cent. of the crop has been recorded to be caused by the disease.

Minute, reddish-brown spots appear on the bolls ; these increase in size, and the inner part of each spot blackens, the margin remaining reddish-brown. Pustules appear in the centre of the spot and give it a grey or pink colour. Attacked fruits do not mature properly ; they usually become dry and dead without opening, or may open only slightly at the top.

In some cases, the stems of seedlings are attacked, the fungus affecting that part of the stem just above ground, and the plant withers and dies as if it were 'damping off'. Such leaves as have become in some way weakened are those which are usually attacked. The cotyledons are sometimes affected, especially when they have become bruised or injured in some manner.

Diagnosis :—

> Sori orbicular, dark-coloured or covered with a pink powder; acervuli erumpent: conidia irregularly oblong, hyaline, flesh-coloured in mass, 11 – 20 × 4·5 – 5·5 *Microns*; conidiophores colourless, at least longer than the conidium, 12 – 28 × 5 *Microns*; setae single or in tufts, blackish-brown at the base, almost hyaline at the apex, septate.
>
> Atkinson. *Journ. Myc.*, Vol. VI, p. 173.
> Southwell. *Journ. Myc.*, Vol. VI, p. 100.
> Lewton-Brain. *West Ind. Bull.*, Vol. IV, p. 265.

Colletotrichum luxificum, van Hall & Drost. (Witches' Broom of Cacao.) The disease was reported to occur in Surinam in 1898, and in 1906 it was observed in cacao plantations in Demerara. Professor Ritzema Bos, of Amsterdam, concluded that the disease was caused by a fungus which he named *Exoascus theobromae*. No one else, however, had been able to find fructifications of the *Exoascus* type on the diseased parts, and quite recently Dr. C. van Hall and Mr. A. W. Drost have proved the disease to be caused by one of the Melanconiaceae, which they have named *Colletotrichum luxificum*.

When a tree is attacked by the fungus, hypertrophied shoots are produced in bunches, assuming the character of a 'witches' broom'; these branches are enlarged, show a tendency to grow vertically and have well-marked longitudinal furrows at their basal end. Finally, the whole structure thus formed dies. The infloresence is also attacked, with the result that a dense mass of flowers is produced, this being due to the branching of many of the pedicels; the flowers in these clusters are usually abortive. The fungus has also been shown to be capable of infecting the fruits directly; such fruits as are attacked show a hardening of the tissues of the infected area, swelling of the fruit-stalks, and a blackening of the diseased patch. Pods which are diseased seldom mature, and a large quantity of them perish.

Diagnosis :—

> Stromata isolated, forming small masses of a dirty white or sometimes of a rose colour; conidia continuous, hyaline, oval or ovoid, sometimes slightly constricted at the middle, 13-19 *Microns* long, 4-5 *Microns* broad, usually with a very refringent region at the centre of each; setae multi-septate, black or fuscous 50-120 *Microns* long, 3·5-4·5 *Microns* broad at the base, 1·2-2 *Microns* broad at the apex.

Hall & Drost. *Recueil des Trav. Bot. Néerl., Soc. Bot. Néerl.* IV, p. 243 (1908).
Ritzema Bos. *Tydschrift over Plantenziekten*, p. 65, (1900).
Kew Bulletin, No. 5, 1909.
Howard. *West Ind. Bull.*, Vol. II, p. 205.

Pestalozzia palmarum, Cooke. (Cocoa-nut Leaf Disease.) This disease has been reported to occur in Trinidad and in Cuba. The fungus appears to be only a weak parasite. When the plant is attacked the leaves droop and the tips of the leaves die; yellowish spots appear on them and these frequently run together. The colour of the spots goes to a greyish-white with a greenish-brown margin. Finally, all the leaves become attacked, their internal tissues being destroyed. The leaf area of the plant is thus reduced and the plant is weakened, with the result that the yield of fruit is considerably diminished; the nuts produced are few and small.

Minute pustules of a dark grey colour are produced on the leaves, constituting the only known form of reproduction of the fungus.

Diagnosis :—

Erumpent, blackish, gregarious or scattered; conidia fusiform, 4-septate, blackish, stalk elongated, hyaline, 15 x 5-6 *Microns.*

Stockdale. *West Ind. Bull.*, Vol. VI, p. 313.
" " " " " IX, p. 371.
Cooke. *Grev.*, Vol. V, p. 102, pl. 86.

Septoria nicotianae. This fungus causes 'Frog-eye' disease of tobacco and is reported as occurring in Jamaica.

HYPHOMYCETES.

MUCEDINACEAE.

Pellicularia Koleroga, Cooke. (Coffee Leaf-rot.) The disease was first noticed in Mysore, Southern India, where it was known as 'leaf-rot' or 'Koleroga'; later on Dr. Ernst found it to occur in Venezuela, and more recently it has made its appearance in Jamaica. [It has also been reported as occurring on the leaves and small branches of cacao in Trinidad. (F.W.S.)]

The fungus covers the leaf with a slimy gelatinous matter, and the mycelium is external to the host. Affected leaves turn black, rot at their tips, and fall off.

Diagnosis :—

Effuse, greyish-white, covering the whole leaf-surface; conidia globose, hyaline, echinulate, 7·5 *Microns* diam., inserted laterally, sessile.

Saccardo, Vol. IV, p. 149.
Kew Bulletin, 1893, p. 67.
Cooke. *Coffee Diseases.*
Hart. *West Ind. Com. Circular*, Vol. XXIV, p. 510.

Ramularia areola, Atkinson. (Areolate Mildew of Cotton.) The fungus attacks the leaves of the cotton plant; it seems, however, only to damage older leaves, and is not very important. Definite, small areas of the leaf become diseased; these areas are bounded by the veins and appear yellowish and frosted.

Diagnosis :—

Spots on under side of leaf, rarely on both, at first pale, then darker in colour, 1-10 mm. broad, irregular, bounded by veins of the leaf; hyphae in small fascicles, many-septate, hyaline, 25-75 x 4·5-7 Microns; conidia oblong, 1-3-septate, formed in chains at first, 14-30 x 4-5 Microns.

Lewton Brain. *West. Ind. Bull.*, Vol. IV, p. 63.
Stockdale. *West Ind. Bull*, Vol. VIII, p. 159.

Ramularia necator, Massee.* This fungus developed on the cotyledons of seedling cacao from Dominica and Jamaica, when the seeds were planted at Kew. The fungus was shown to have come from the West Indies. It resulted in the death of the plants attacked.

Diagnosis :—

Sporodochia superficial, broadly effuse, filamentous white; sterile hyphae creeping, densely interwoven, septate, hyaline, 7-10 Microns wide, slightly swollen here and there. Basidia erect, sparsely branched, the ultimate branches attenuate, conidia elliptico-oblong, rounded at either end, 3-septate, scarcely constricted at the septa, 25-28 x 7-9 Microns.

Massee. *Kew Bull.*, 1907, pp. 243 and 298.

DEMATIACEAE.

Cercospora coffeicola, B. and C. Has been reported to occur on coffee leaves in Trinidad.

Diagnosis :—

Spots amphigenous, 2-3 mm. in diameter, light-coloured or white in the centre with a reddish-brown margin; hyphae mostly epiphyllous, tufted on the small tubercular base, 50-75 x 4 Microns, 2-3-septate, fuscous, butalso elongated to 100 or 350 Microns, nodulose and toothed above; conidia hyaline, 2-4-septate, 75 x 3 Microns at the thickest end.

Journ. Myc., Vol. IV, p. 5.

Cercospora gossypina, Cooke. (Leaf-spot of Cotton.) This disease is known as 'black-rust' in the United States of America; it frequently occurs along with the cotton anthracnose. Dark-coloured spots are produced on the leaves, the centres of the spots later becoming lighter in colour and bearing the spores of the fungus. The fungus seems to be of little practical importance in the West Indies.

Diagnosis :—

Hyphae almost fasciculate, elongated, dark-coloured; conidia elongated, five-to seven-times septate, hyaline 70 - 100 x 3 *Microns*.

Cooke. *Grev.* XII, p. 31.
Lewton-Brain. *West Ind. Bull.*, Vol. VI, p. 120.
Bot. Gaz., p. 61, 1891.

Cercospora personata, Ellis. (Leaf-spot of Ground Nut.) This disease has recently occurred in Dominica. The fungus forms brown, almost circular spots on the under surface of the leaves, about 2-4 mm. in diameter.

Diagnosis —

Hyphae densely caespitose, short, brown, continuous; conidia clavate, pale-brown, 3-septate, 30-50 x 5-6 *Microns*.

Ellis. *Journ. Myc.*, 1885.

Cercospora vaginae, Kr. (Red Spot of Sugar-cane). This disease occurs in the West Indies, India and Java. The fungus causes large, red spots to form on the leaf-stalk, the spots being confided to the leaf-stalk only.

Several other species of *Cercospora* occur on the sugar-cane :—

C. sacchari, Breda de Hann. (Eye-spot of Java.)
C. Köpkëi, Kr. (Red Leaf-spot of Java.)
C. acerosum, D and H. (Black Spot of Java.)
C. longipes, Butler. (Brown Leaf-spot of Bengal.)
Butler. *Memoirs Agric. Dept. in India*, Vol., I, No. 3.

Cladosporium elegans, Penzig. (Disease of Orange.) In addition to the orange, the fungus attacks various citrus trees. It has proved to be injurious in the Southern States of America and in Cuba, as well as in Southern Europe.

The disease appears as white or cream-coloured spots on the leaves, young twigs and fruit. When the leaves are badly attacked, they become curled and are covered with wart-like eruptions.

Diagnosis :—

Tufts epiphyllous, gregarious, distinct, seated on arid spots ; conidiophores erect, fasiculate, simple, sparingly septate, distinctly sinuous, brown, 160-200 x 5-6 *Microns* : conidia apical and lateral, continuous or 1-septate, elliptic-oblong, epispore delicately granulated, pale-brown or yellowish, 18-20 x 5-6 *Microns*.

Cooke and Horn. *Bull. 9, Estacion Central Agron. de Cuba.*
Massee. *Text-book Plant Dis.* p. 436.
Tubeuf & Smith. *Diseases of Plants*, p. 509.

Thielaviopsis ethaceticus, Went. This fungus causes a disease of sugar-cane cuttings, known as the 'pine-apple disease'. The same fungus has been described as attacking pine-apple fruits in Hawaii.

The disease causes great damage in a dry season, when germination and growth are slow. The fungus effects an entrance at the cut ends of the cutting, as a rule, but it can enter at any wounded surface. The mycelium pervades the tissues of the stem, and the interior of diseased stems, on examination, is found to contain a black mass of hyphae and spores, and has an odour of pine-apple. The growth of the cutting is checked, and the plant finally dies.

Diagnosis :—

Sterile hyphae almost hyaline; fertile hyphae simple and septate; conidia of two kinds, the macroconidia ovate and blackish, the microconidia hyaline and cylindrical, originating within the ruptured apex of a hypha.
Macroconidia 16 – 19 × 10 – 12 Microns.
Microconidia 10 – 15 × 3·5 – 5 Microns.
Lewton-Brain. *West. Ind. Bull.*, Vol. VI.
Went. *Archief voor de Java Suikerindustrie*, 1893.

(Unidentified.) (Leaf Mildew of Cotton.) The leaves of the cotton plant sometimes turn yellow or red in irregular areas, and finally the whole leaf becomes yellow and falls off. The disease was said to be serious in Montserrat in 1904. Little or no work seems to have been done on it, and the fungus is at present unnamed.

(Unidentified.) (Pine-apple Blight.) This disease, although hitherto not yet fully investigated, seems to be due to a fungus which is parasitic on the roots of the pine-apple plant. In the incipient stages of the disease the tips of the leaves become withered and of a yellow colour; this discoloration extends further, and most of the leaves are found to have lost their turgidity and to have become withered. The plant eventually dies, the apical leaves and shoots becoming decayed at their bases of attachment and dropping off. If these plants bear fruits, they are usually stunted, and become yellow some time before the proper time of ripening. The tips of the roots and rootlets, on examination, are seen to be discoloured and flaccid, instead of maintaining their usual turgidity, and in many cases the roots are quite black and rotten. Numbers of root-hairs occur on the older parts of the roots, where they are normally absent. The root-hairs and tissues of the root contain abundant fungus mycelium, and it seems as if the abnormal formation of root-hairs on the older parts of the roots was an effort on the part of the roots to replace those hairs destroyed by the fungus. Finally the roots become decayed and rotten, and the decay can be traced upwards into the stem. The fungus has not yet been identified, and apparently no experiments have been conducted with a view to ascertaining whether or not it is the cause of the disease.

Stockdale. *West Ind. Bull.*, Vol. VIII, p. 159.
Lewton-Brain *West Ind. Bull.*, Vol. VI, p. 120.

(Unidentified.)* (Root-rot of Cassava and Logwood.) A white mycelium attacking the roots of logwood trees was

found in Jamaica by Professor F. S. Earle, who was of the opinion that it belonged to some member of the Hymenomycetes.

The fungus caused the death of the trees and then spread outwards in a circle underground, affecting fresh healthy trees. Cassava plants growing in the neighbourhood of dead logwood trees also showed a similar disease.

West Ind. Bull., Vol. IV, pp. 2 and 8.

APPENDIX I.

A. DISEASES ASCRIBED TO BACTERIA.

ANGULAR LEAF SPOT OF COTTON. The disease appears as small angular spots on the leaves, which are usually bounded by the smaller veins. The spots are at first of a watery appearance, but later turn light-brown and black.

Frequently the spots form dark lines along the main veins an inch or more long and ¼-inch wide.

The disease is due to a bacterium, *Pseudomonas malvacearum*. It is not of much importance, except in rare instances.

Lewton-Brain. *West Ind. Bull.*, Vol. IV, p. 345.
Atkinson. *The Cotton Plant*, p. 286.

COTTON BOLL ROT. The rot begins within the boll as a small dark-brown area, which includes the young seeds, starting at a point near the point of attachment of the boll to the stalk. The rot spreads throughout the contents of the boll, and when they are all decayed, attacks the outside of the boll itself. When the disease affects a young boll, the decay is complete, and the boll does not open; but when it develops on an older boll, only a small part of the lint is affected and the boll opens.

The disease has been shown to be due to a bacterium, *Bacillus gossypinus*, but the method of infection has not yet been definitely ascertained.

Lewton-Brain. *West Ind. Bull.*, Vol. IV, pp. 265 and 345.
Atkinson. *The Cotton Plant*, p. 310.

BLACK BOLL OF COTTON. This disease appears to be characterized by decay of the internal parts of the boll, usually starting at the base, while the outside is apparently healthy. The seeds swell up inside during the latter stages, probably owing to a form of premature germination, and all the lint is destroyed. The bolls, as a rule, drop from the plant before opening. Such bolls, instead of being oval, are practically spherical, and taper very suddenly to a sharp point; they are also more resistant to pressure than normal bolls. Occasionally they dry up on the plant and open slightly. When this is the case, they are easily distinguishable from bolls which have dried physiologically, by the condition of the lint.

A short, non-motile, rod-like bacillus is the only organism that has been found in connexion with the disease, though it has not been definitely proved that this is the cause, as inoculation experiments have not been carried out. Climatic and soil conditions do not appear to exercise any influence on the disease, which occurs on various soils both in Montserrat and Antigua.

Lewton-Brain. *West Ind. Bull.*, Vol. VI, p. 119.

BANANA LEAF-BLIGHT. The disease first appears in the form of a browning of the vascular bundles of the leaves. This is soon followed by a blackening of the entire leaf-blade and the decay of the leaf and petiole. The terminal bud remains free from disease, but the new leaves which it puts out are attacked in turn, so that only three or four healthy leaves are left. Infected plants are much stunted in growth and do not bear fruit. Professor Earle attributes the disease to bacteria. It was first found in Jamaica.

Earle. *West Ind. Bull.*, Vol. IV, p. 6.

BUD-ROT OF COCOA-NUT PALMS. The first symptoms of this disease are the yellowing and dropping of the outer leaves, followed closely by dropping of the nuts. Finally the whole of the terminal bud becomes converted into a putrefying mass with a very unpleasant sour smell, and the tree is completely killed.

Numerous fungi and bacteria have been found in connexion with this disease, but at present none of them has been definitely proved to be the cause, though the smell of putrefactive fermentation seems to indicate a bacterial origin.

The disease is of serious dimensions in the West Indies, and occurs in Jamaica, British Honduras and Cuba, and more recently has been found in Trinidad and British Guiana. A disease which appears to be very similar in its symptoms has also been found to occur in various parts of the eastern hemisphere.

West Ind. Bull., Vol. VI, p. 307 where numerous additional references to the chief papers dealing with the subject will also be found.

GENERAL. Root diseases of arrowroot, eschalots, ginger, potatos and yams have been reported from various islands, as well as diseases affecting cabbage leaves and tomato fruits, and are attributed to bacteria. The diseases are of minor importance in most cases, and their complete investigation and identification have not yet been undertaken.

B. DISEASES DUE TO PHYSIOLOGICAL CAUSES.

SHEDDING OF COTTON BOLLS. The fruits and fruit-stalks first become of a paler colour than the healthy parts, and eventually either fall completely, or hang by a few threads. This is not due to any definite organism but to general physiological

conditions in the plant caused by unfavourable conditions, such as a sudden change from wet to dry weather, or the reverse.

Atkinson. 'Some Diseases of Cotton', *Alabama College Station Bulletin, No. 41.*

Lewton-Brain. *West Ind. Bull.*, Vol. IV, pp. 264 and 346.

MAL-DI-GOMMA OF THE ORANGE. This disease, also known as 'Foot Rot', is fairly common in several countries, especially in Florida, U. S. A. It has also been found in Jamaica and Cuba. The first symptom of the disease is an abundant exudation of drops of gum on the trunk of the tree near the base. Then the inner bark becomes soft and has an unpleasant odour, while the outer bark splits away. The cambium under the diseased spot is killed, and finally the bark dries up and splits off.

The disease spreads to the crown and main roots, and in severe cases girdles the tree and kills it in about two years. In mild cases the tree may recover. The bark is only destroyed for 1½ feet above the ground, but on the main roots the disease extends further. Diseased trees have the appearance of suffering from lack of nourishment.

No definite organism has been found in connexion with early stages of this disease, but recently it has been shown that gumming diseases in general are mainly due to physiological conditions, such as excessive irrigation or drought, or imperfect aeration of the roots, and similar causes; and at present it seems probable that Mal-di-Gomma is also attributable to these.

Swingle and Webber. 'The Principal Diseases of Citrous Fruits in Florida', *Bull. No. 8., U. S. Depart. Agric. Div. of Veg. Phys. and Path.*

Smith and Butler. 'Gum Diseases of Citrous Trees in California', *Bull. No. 200., Agric. Exp. Sta.*, California.

MELANOSE. This disease occurs as small dark-brown spots on the leaves, stems and fruits of various citrus trees in America, it has also been found in Montserrat.

The spots increase in size, and may split in the centres. Many of the leaves fall, and the branches become twisted and contorted, in severe attacks; consequently the health of the trees is considerably impaired, while the fruit is rendered worthless for market purposes.

No living organism has ever yet been found in connexion with the disease, which must therefore be attributed to physiological causes. The latter, however, do not seem satisfactorily to account for it, as it will yield to the application of fungicides, and seems to be infectious, generally spreading in the direction of the prevailing wind.

Swingle and Webber. 'The Principal Disease of Citrous fruits in Florida', *Bull. No. 8., Div. of Veg. Phys. and Path.*, U. S. Dept. of Agric.

PINE-APPLE TANGLE ROOT. The leaves of pine-apples turn yellow, then wilt and dry up. The roots exhibit a peculiar appearance, being wound round and round the plant under the leaves and forming a tangled mass.

The disease is due to improper preparation of the land before planting, which prevents the roots from entering the ground freely. Consequently they wind round the plant, and strangle it.

The disease has been observed in Dominica, Antigua and Jamaica, as well as in other parts of the world.

Stockdale. *West Ind. Bull.*, Vol. VIII, p. 58.

APPENDIX II.

A. TRICHOSPHAERIA SACCHARI, MASSEE, AND THIELAVIOPSIS ETHACETICUS, WENT.

Two forms of fruiting body, namely, the ascigerous stage and the *Melanconium* stage, have for some time been recognized as belonging to *Trichosphaeria sacchari*. Besides these, Massee [5] states that an endospore condition consisting of macro- and micro-conidia very frequently developed in pure cultures of the *Melanconium* fungus in the Laboratory at Kew. Prillieux and Delacroix [6] confirm this, and more recently Lewton-Brain [3] has also obtained them in Hawaii. But Howard [8], Went [9] and Butler [1], here, in Java, and in Bengal have not been able to obtain them, probably owing, as Thiselton Dyer [8] suggests, to the difference of temperature conditions.

There appears to be no reason for doubting that this fungus has an endoconidial stage; but it does seem inadvisable to assume with Massee [4], and Prillieux and Delacroix [6] that the endospore condition of *Trichosphaeria sacchari* is identical with *Thielaviopsis ethaceticus*, Went, the fungus causing 'Pine-apple disease' of sugar-cane cuttings. Went [9] also claimed that the endospore condition obtained in Massee's cultures of *Melanconium* spores, was the same as *Thielaviopsis ethaceticus*, but that it was present as an impurity in the culture. Subsequent cultures from single spores of *Melanconium* have proved that this is not the case.

Butler has shown that a fungus occurring on cane cuttings to which he gave the name *Sphaeronema adiposum* is also capable of forming endospores, and suggests that possibly these may be identical with the 'pine-apple' disease; but he adds that several other fungi can form endospores, and that the 'pine-apple' fungus which he grew for a considerable period on various media never gave him any other spore-forms than the macro- and micro-conidia.

The arguments in favour of the idea that *Thielaviopsis ethaceticus* is identical with the endoconidial stage of *Trichosphaeria sacchari* may be summarized as follows:—

(1) As shown by Massee[5], *Trichosphaeria sacchari* forms endoconidia in cultures, which closely resemble those of *Thielaviopsis ethaceticus.*

(2) The two fungi in question have been found in the same sugar-cane.

(3) Howard [2] reports that *Thielaviopsis* occurred in diseased pine-apples in Antigua, and Stockdale [7] reports that *Trichosphaeria* occurs there also, causing a smell of ethyl acetate.

(4) Lewton-Brain[3], while refraining from the expression of any definite opinion, remarks that the identity of the two forms would make it a simpler matter to account for the prevalence of *Thielaviopsis ethaceticus.*

The arguments that oppose these are:—

(1) The occurrence of an endoconidial stage of *Sphaeronema adiposum* and several other fungi as mentioned by Butler[1].

(2) The fact that pure cultures of *Thielaviopsis ethaceticus* have not yet been found to produce any spore-forms other than the endoconidia.

(3) The 'Pine-apple disease' of cane cuttings first arose in Java, where *Trichosphaeria sacchari* is very seldom found, and then only on dead canes[8].

(4) The name 'Pine-apple disease' was given to the effect of *Thielaviopsis ethaceticus* owing to the smell of pine-apple which accompanies it. This smell is a very constant character and is not caused by the mycelium of *Trichosphaeria sacchari.*

Consequently it seems advisable not to definitely identify *Thielaviopsis ethaceticus* with the endoconidial stage of *Trichosphaeria sacchari* in the present stage of our knowledge; although the formation of endoconidia by the latter fungus must be considered as proved. This course has therefore been adopted in Mr. Bancroft's paper

REFERENCES.

1. Butler.—*Memoirs of the Department of Agriculture in India,* I. 3.
2. Howard.—*West Indian Bulletin,* III, p. 74.
3. Lewton-Brain.—*Bulletin of Experiment Station,* No. 7, Hawaiian Sugar Planters' Association.
4. Massee.—*Kew Bulletin,* 1904.
5. „ *Ann. Bot.* VII.
6. Prillieux and Delacroix.—*Bulletin Soc. Myc. de France,* XI, pp. 81 and 82.
7. Stockdale.—*West Indian Bulletin,* VIII, p. 163.
8. Thiselton Dyer.—*West Indian Bulletin,* II, p. 211.
9. Went.—*Ann. Bot.* X, pp. 583-600.

B. THE NOMENCLATURE OF THE GENUS DIPLODIA AND ITS ALLIES.

This group of fungi comprises several important diseases f plants in the tropics, as certain of its members occur on cacao, cocoa-nut palms, and one or two rubber-yielding trees, in addition to mangos and citrus trees.

The group is divided up into several genera in accordance with the following characters:—

Those fungi in which the pycnidia are always isolated, and without a stroma, belong to the genera *Diplodia*, *Microdiplodia*, *Macrodiplodia*, *Chaetodiplodia*, etc.; while those with pycnidia occurring in groups on a stroma, belong to the genera *Botryodiplodia*, and *Lasiodiplodia*. These last two genera are separated by the facts that in the genus *Botryodiplodia* the stroma is smooth and the pycnidia are without paraphyses, while in that of *Lasiodiplodia* the stroma is covered with a soft felt of hairs, and the pycnidia contain paraphyses. These, then, are the theoretical lines on which the genera are separated. Unfortunately, none of the characters mentioned are truly fixed, with the exception of the presence or absence of paraphyses in the pycnidia. Certain fungi in this group may individually show some or all of them, according to the position of the fructifications on the host plant, and the depth within the tissues at which they are formed. As may be readily understood, the variability of the characters upon which the divisions between the genera are based has caused a considerable amount of confusion in the nomenclature, besides a serious multiplication of names for the same fungus. This has a practical bearing of some importance, in addition to its rather academic one, as it prevents the recognition of the very general occurrence of one or two of these species in the tropics, and the large variety of host plants which they can attack.

An instance of this is the fungus known in the publications of this Department as *Diplodia cacaoicola*, Henn. It has been shown by Howard [5] that this fungus attacks both cacao and sugar, on the former of which it causes 'Die-back' of the branches and 'Brown rot' of the pods. On the young branches of cacao it forms fructifications that are more usually isolated, but contain paraphyses; and on the strength of these characters it was identified with *Diplodia cacaoicola*, Henn. On older branches and the main stem, however, the fructifications are more usually grouped in a stroma and are generally covered with a velvety layer of hairs. On this account, Patouillard and Lagerheim claim that it is identical with *Botryodiplodia theobromae*, Pat., while Butler [2], in discussing specimens found on sugar-cane, remarks that it is more properly a species of *Botryodiplodia*. But these authors all overlook the presence of the paraphyses in the pycnidia, on account of which the fungus must be regarded as a *Lasiodiplodia*. These points are all clearly indicated by Griffon and Maublanc [4] in the *Bulletin de la Société Mycologique de France*, Tome XXV, 1er Fasicule in an article entitled 'Sur une Maladie du Cacaoyer'. These

authors describe the same fungus from the French Congo and point out that it is, according to the present system of classification, a *Lasiodiplodia*, and that the various names mentioned above have all been given to the same fungus, the correct name of which is *Lasiodiplodia theobromae*, Griff. and Maubl. Their statements are for the most part based on comparisons of different specimens, and recent observations made in the laboratory of the Imperial Department of Agriculture confirm them.

Another species of fungus was described by Stockdale [10] as attacking the stems and roots of cacao in the West Indies, to which the name *Lasiodiplodia* sp. has been given. The appearance of this agrees exactly with the description of the form of fructification occurring on roots and main stems of cacao attacked by *Lasiodiplodia theobromae* as described by Griffon and Maublanc, and also by Maublanc [7] alone. Further it has lately been found here on a specimen of cacao whose twigs showed typical symptoms of 'Die-back', while the older branches and stem showed every transition between the pycnidia typical of *Diplodia*, that is they were characteristically isolated, and those typical of *Lasiodiplodia*, that is in a stroma covered with hairs. The pycnidia, whether isolated or not, always contained exactly identical spores and paraphyses, and the former even often showed a few hairs round the ostiole. Consequently it seems that the disease of the stem and roots, and that on the twigs and pods are identical, and due to one fungus, *Lasiodiplodia theobromae*, and not to two distinct species, *Diplodia cacaoicola* and *Lasiodiplodia* sp., as was formerly considered to be the case.

The form known in the publications of this Department as *Lasiodiplodia* sp. was identified in America and considered to be the same as that described by Charles [3] as occurring on cacao and the mango in San Domingo. As a result, the fungus described by Charles must be considered to have been *Lasiodiplodia theobromae*; and this was believed to be the case by Griffon and Maublanc. These authors also point out that the form described by Appel and Laubert [1] as *Lasiodiplodia nigra*, found on cacao in Samoa, is probably the same as *Lasiodiplodia theobromae*. The same authors found this fungus on *Albizzia moluccana* in Madagascar, and recent observations would seem to indicate that it may occur on other host plants than sugar and cacao in the West Indies. The recognition of the wide distribution of this fungus, and the variety of host plants which it can attack, are of considerable importance when dealing with the fungus from an economic point of view.

To summarize:—

(1) The fungus known as *Diplodia cacaoicola*, Henn., is more properly called *Lasiodiplodia theobromae*, Griff. and Maubl.

(2) The one fungus *Lasiodiplodia theobromae* is responsible for 'Brown rot' of cacao pods, 'Die-back' of twigs, and the stem and root disease of cacao formerly attributed to *Lasiodiplodia* sp.

(3) The synonyms of *Lasiodiplodia theobromae*, Gr ff. and Maubl. are *Macrophoma vestita*, Prill. and Del. [9]
Diplodia cacaoicola, Henn.
Botryodiplodia theobromae, Pat.
Lasiodiplodia sp., and in all probability
Lasiodiplodia nigra, Appel and Laub.

(4) In addition to cacao, the fungus can attack sugar-cane, mangos, and *Albizzia moluccana*.

(5) From what has been said, it seems sufficiently evident that the whole group is in great need of careful revision, the divisions being based on characters which are as constant as possible and independent of the position on the host and the depth within its tissues at which the pycnidia are borne. Furthermore, this revision is one of considerable importance from the economic point of view.

REFERENCES.

1.—Appel and Laubert. *Arb. aus der Kaiserl. Biol. Anst. fur Land-und Fortswirts* V. 3, 1906, p. 147.

2.—Butler. *Memoirs of the Dept. of Agric. in India*, Vol. I, p. 29.

3.—Charles. *Journal of Mycology*, XII, pp. 145 and 146.

4.—Griffon and Maublanc. *Bull. Soc. Myc. de France* XXV, pp. 51-8.

5.—Howard. *Anns. Bot.*, XV.

6.— „ *West Ind. Bull.*, II, No. 3.

7.—Maublanc. *L' Agriculture Pratique des Pays Chauds*, 1909, No. 79.

8.—Patouillard and Lagerheim. *Bull. Soc. Myc. de France*, VIII, p. 136.

9.—Prillieux and Delacroix. „ „ 1894, p. 165.

10.—Stockdale. *West Ind. Bull.*, IX, p. 177.

[While this paper was in the press *Bulletin* No. 21 of the Department of Agriculture in Surinam, by A. E. van Hall and A. W. Drost, was received at the office. The results arrived at by these observers substantially support what has been said above, but they suggest the abolition of the genus *Lasiodiplodia* on the ground that the characters separating it from *Diplodia* are not constant. Consequently they retain the old name *Diplodia cacaoicola* instead of *Lasiodiplodia theobromae*. F.W.S.]

APPENDIX III.

INDEX OF HOST PLANTS.

APPENDIX IV.

INDEX OF PARASITES.

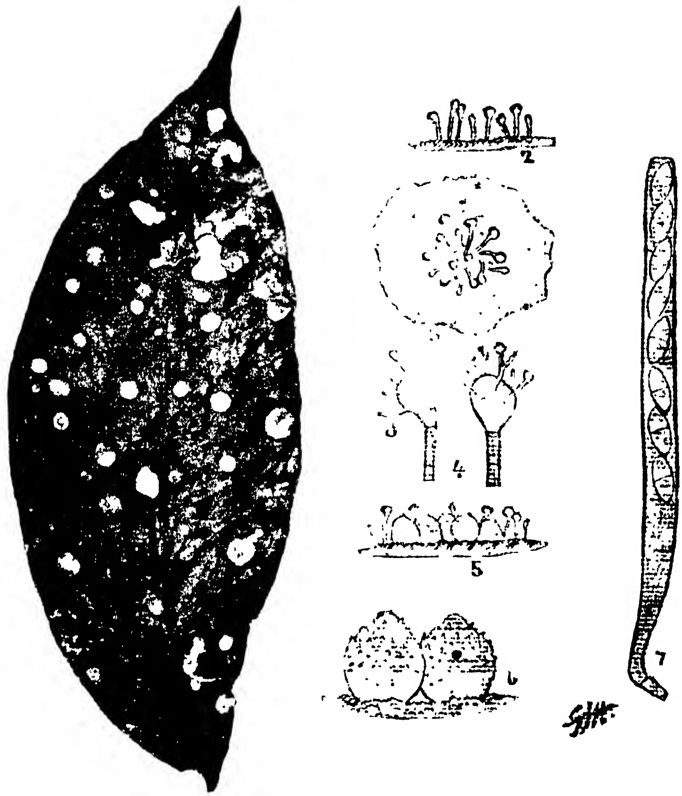

FIG. 20. SPHAEROSTILBE FLAVIDUM, Massee.
(Kindly lent by H.M. Stationery Office.)

1. Leaf of coffee plant, showing the circular whitish patches.
2. Hyphae with swollen heads on surface of a patch.
3. A group of such hyphae.
4. Two hyphae forming conidia from their swollen heads.
5. Fertile hyphae and perithecia
6. Two perithecia.
7. An ascus with spores.

(After Massee.)

MANURIAL EXPERIMENTS WITH COTTON IN THE LEEWARD ISLANDS.

BY H. A. TEMPANY, B.Sc., (Lond.), F.I.C., F.C.S.,
Government Chemist and Superintendent of Agriculture for the Leeward Islands.

Since 1904-5, manurial experiments with cotton have been carried out in the Leeward Islands. The results for this and the following year, only, were published in the *West Indian Bulletin*, Vol. VI, p. 247 : and Vol. VII, p. 283. Similar experiments have, however, continuously been carried out, and the following is an account of the results obtained during the past year. The original series consisted of thirty-eight experiments. The nature of the manurial treatment will be found by reference to the tables which follow. During the past season, these thirty-eight experiments were carried out in triplicate at the experiment station at La Guérite, St. Kitts, and experiments 1 to 34 on single plots on Dagenham estate, Montserrat. The results obtained in each case are given in Table I.

Of the trials at La Guérite, the nitrogen and phosphate series were planted in June and July, respectively, while the potash series was planted in August. Commenting on these results, Mr. F. R. Shepherd, Agricultural Superintendent of the Botanic Station, St. Kitts, now says :—

'The no-manure plot (No. 1 this season in the nitrogen series) is slightly below the average of previous years, but in the phosphate and potash series, it is again well up to the average of the manured plots. The influence and action of the manures again this year have shown no marked difference on the yield of cotton, except in one or two individual cases.

'Taking the results on the average of five years, the no-manure plot occupies a high position, being 77 ℔. beyond the mean of all the thirty-five plots under experiment, the no-manure plot giving an average of 1,310 ℔. per acre, and the mean of all the plots being 1,241 ℔.

'Considering these results on this basis, it seems clear that on this land, and under these conditions, the use of artificial and other manures is not remunerative, but that good tilth and soil conditions, with average seasons, are more likely to influence the yield of cotton than manure.

'It may be interesting to mention that, in addition to the two no-manure plots under experiment, there were also five other plots of the same size which have been dealt with in a similar manner each year, and the average yield of seed-cotton from these for the five years is 1,160 ℔. per acre.'

In Montserrat, experiments Nos. 1 to 24, only, were carried out, there being no cotton seed meal, or salt and sulphate of copper series. The yields obtained from all the plots were large; in the case of some of them, appreciable increases are shown; the plots which yielded these were Nos. 2, 7, 9 and 15. The largest return was given by plot 9, in which 20 ℔. of nitrogen was applied as sulphate of ammonia, alone, the increase being 312 ℔. of seed-cotton.

TABLE

MANURES AND YIELDS

No. of Experiment.	Nitrogen as nitrate of soda.	Nitrogen as sulphate of ammonia.	Potash as sulphate of potash.	Phosphoric acid as basic phosphate.	Cotton seed meal.	Salt.
1	...	...	No manure		...	...
2	...	...	Pen manure		...	...
Nitrogen Series						
3	...	...	30	40	...	...
4	...	20	30	40	...	...
5	..	30	30	40	...	...
6	20	...	30	40	...	...
7	30	...	30	40	...	...
8	...	30	30	..	...	...
9	..	20	...	...	...	..
10	..	30	...	...	..	...
11	20	...	..	...	...	...
12	30	...	...	...	...	..
Phosphate Series						
13	...	30	30	...	...	...
14	...	30	30	40	...	...
15	...	30	30	60	..	..
16	...	30	30	80	...	...
17	...	.	...	40	...	...
18	...	30	30	40*	...	...
19	...	30	30	60*	...	...
Potash Series						
20	...	30.	...	40	...	...
21	...	30	20	40	...	...
22	...	30	30	40	...	...
23	...	30	40	40	...	...
24	...	...	40	...	...	...
Cotton Seed Meal Series						
25	...	...	...	...	300	...
26	...	...	..	...	600	...
27	...	...	30	...	300	...
28	...	...	...	40	300	...
29	...	...	30	40	300	...
30	...	30	30	40	300	...
Salt Series						
31	...	...	...	...	...	100
32	...	...	...	...	...	200
33	...	30	30	40	...	100
34	...	30	30	40	...	200
35	...	...	...	...	300	100
Sulph. of Copper Series						
36	...	...	...	...	...	...
37	..	30	30	40	...	...
38	.	...	...	...	300	...

* Phosphoric acid as superphosphate.

I.

IN POUNDS PER ACRE, 1909.

Sulphate of copper	La Guérite. I	II	III	Montserrat.	Average.	Difference on No manure.
...	1,000	1,042	830	1,605	1,119	...
...	1,225	900	765	1,825	1,179	+ 60
...	1,200	852	927	1,587	1,142	+ 23
...	1,030	900	730	1,545	1,051	− 68
..	1,190	835	855	1,680	1,140	+ 21
..	1,085	755	745	1,610	1,049	70
...	1,285	760	810	1,872	1,182	+ 63
...	1,372	630	670	1,702	1,094	− 25
...	1,250	760	807	1,917	1,184	+ 65
...	1,310	1,035	865	1,665	1,219	+ 100
...	1,380	940	687	1,647	1,164	+ 45
...	1,140	935	762	1,647	1,121	+ 2
...	1,372	630	670	1,702	1,094	− 25
...	1,190	835	855	1,680	1,140	+ 21
...	1,350	825	800	1,752	1,182	+ 63
..	1,297	1,122	635	1,717	1,193	+ 74
...	1,115	1,175	952	1,642	1,221	+ 102
...	1,435	975	715	1,492	1,154	+ 35
...	1,202	729	890	1,412	1,056	− 63
...	972	1,076	915	1,595	1,139	+ 20
...	820	895	790	1,397	976	− 143
...	1,190	835	855	1,680	1,140	+ 21
...	917	1,025	850	1,610	1,101	− 18
...	1,235	935	850	1,602	1,156	+ 37
..	1,330	1,175	892	..	1,132	+ 13
..	1,095	905	857	...	952	− 167
...	1,180	932	820	...	977	− 132
...	1,358	865	900	..	1,041	− 78
...	1,047	1,070	940	...	1,019	− 100
...	922	950	670	...	847	− 272
...	740	685	830	.	752	− 367
...	1,025	1,112	805	...	981	− 138
..	920	1,015	850	...	928	− 181
...	890	850	940	..	893	− 216
...	985	1,015	895	...	965	− 154
20	565	1,145	970	...	893	− 226
20	915	930	1,150	...	982	− 137
20	995	1,150	1,030	...	1,058	− 61

TABLE II.

Manures and yields in pounds per acre.

Mean of five years—33 plots.

No. of Experiment.	Nitrogen as nitrate of soda.	Nitrogen as sulphate of ammonia.	Potash as sulphate of potash.	Phosphoric acid as basic phosphate	Cotton seed meal.	Salt.	Sulphate of copper.[a]	Seed-cotton.	Difference on No manure.
1	...	..	No manure		...	...	...	898·0	...
2	...	...	Pen manure		.	...	...	933·3	+ 35·3
Nitrogen Series.									
3	.	...	30	40	.	..	...	895·5	- 2·5
4	...	20	30	40	...	...		906·1	+ 8·1
5	..	30	30	40	...	...	...	951·3	+ 53·3
6	20	...	30	40	..	...	...	899·6	+ 1·6
7	30	..	30	40	...	...	...	893·4	- 4·6
8	.	30	30	.	...	...	...	924·1	- 26·1
9	.	20	...	...	...	...	...	845·5	+ 52·5
10	...	30	...	...	..	...	...	954·7	+ 56·7
11	20	...	. .	...	..	...	.	945·7	+ 47·7
12	30	...	...	.	...	...	..	910·0	+ 12·0
Phosphate Series									
13	...	30	30	..	.	...	...	924·1	+ 26·1
14	...	30	30	40	...	...	...	951·3	+ 53·3
15	...	30	30	60	...	...	. .	895·7	- 2·3
16	...	30	30	80	...	...	...	916 0	+ 18·0
17	..	...	...	40	...	..	...	869·5	- 28·5
18	...	30	30	40*	...	...	...	869·0	- 29·0
19	...	30	30	60*	...	...	...	832·3	- 65·7
Potash Series									
20	...	30	...	40	...	...	...	866·7	- 31·3
21	...	30	20	40	...	...	...	795·8	- 102·2
22	...	30	30	40	...	...	...	951·3	+ 53·3
23	...	30	40	40	...	...	...	838·8	- 59·2
24	...	...	40	...	...	...	..	860·1	- 37·9
Cotton Seed Meal Series									
25	...	...	...	...	3,000	...	...	876·3	- 21·7
26	...	...	...	..	600	...	...	876·6	- 21·4
27	...	..	30	...	300	...	...	876·3	- 21·7
28	...	...	...	40	300	...	...	933·1	+ 35·1
29	...	...	30	40	300	...	...	836·3	- 61·7
30	...	30	30	40	300	...	...	839·1	- 58·9

* Phosphoric acid as superphosphate.

In Table II, the means are given of experiments in this direction over a period of five years—the result of thirty-three individual experiments in St. Kitts, Montserrat and Antigua. In no instance is any appreciable increase traceable from the application of manures. These have now been repeated a considerable number of times under different conditions, and as a result, one can lay down with some confidence, that under the conditions obtaining in the Leeward Islands, with soils in moderately good tilth, the application of artificial and natural manures to Sea Island cotton is unremunerative. The fact must not be lost sight of, however, that the use of manure is not merely to benefit a particular crop of a certain year, but to maintain the agricultural value of the soil of the estate, as well. In deciding, therefore, what policy shall be followed, in any instance, in the matter of manuring, this latter important fact must be allowed for, in the consideration of the above results.

THE RAINFALL OF NEVIS AND ANTIGUA.

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In the following article an inquiry is made into the rainfall in Antigua and Nevis. This has been done chiefly on account of a suggestion, put forward in connexion with Nevis, that the rainfall of that island is diminishing. The statistics in relation to Antigua are discussed at the same time, in order that information may be obtained as to whether, if such a diminution is taking place, the conditions to which it owes its existence are merely local or more general.

The records of which use has been made are confined to those of the stations where figures are available for several years, and where the rain guage has remained in the same position during the whole of the time. Even then, blanks occur in the series, and the records containing these have been omitted from the compilation, or have had allowance made for them.

The tables that are used in the consideration of the matter have been constructed in two ways. In one, the means for five years of the averages of all stations during those years have been worked out, together with the general mean for the whole period (Tables A 1 and A 2).

According to the other method, the means for seven years, for each station, for every month of the year are given, together with the means, in the same way, for the whole period under consideration. In this case, in addition, the mean rainfall during the last seven-year period has been compared, on the basis of a percentage, with the average of the periods during the whole time under discussion (Tables B 1 and B 2) The purpose of the first method was to find if there has been a general diminution of rainfall during successive periods, and of the second, to discover, in the event of the existence of such

diminution, what particular seasons of the year, if any, have contributed to the general result. The consideration of these two phases of the question will be made in the order of the plan that has just been given.

The following table gives the average rainfall during five-year periods, as far as records are available, for several stations in Nevis, together with the means for five years of all stations, and the average of these. The results cannot be employed for forming any very particularized deductions, on account of the small number of records that have been made at some of the stations, as compared with the others. They ought to show in a general way, however, if any gradual decrease in the rainfall is taking place. Excluding the mean of the three-year period 1876-8, it is seen that the mean rainfall for each *lustrum*, reckoning back from 1908, is within the limits of 44·41 inches to 56·75 inches. Taking the figures in order, it is observed that there may have been, since 1883, two diminishing periods of rainfall, the first commencing with a high average in the period 1879-83, and the second with a high average in 1894-8. It is not intended to deduce the actual existence, from the figures, of such periods, for as has been stated, the final figures are obtained, during successive *lustra*, from differing numbers of stations. There is, however, nothing to show, in the figures for the general averages of stations, that a gradual diminution of the rainfall is taking place. When the figures of the stations themselves, for the last three periods, are considered, a gradual diminution during the time seems to be manifested, but this is no longer the case when periods anterior to those are compared. Unfortunately, in order that this may be done, dependence must be had on one station alone -- Bush Hill - and the statistics that are available are insufficient for any conclusion to be formed in this way.

TABLE A 1. NEVIS. FIVE-YEAR PERIODS.

Estate.	1876-8.	1879-83.	1884-8	1889-93.	1894-8	1899-1903.	1904-8.
Bush Hill ...	60·90	56·75	47·98	41 77	50·09	45·10	44·23
Pinneys ...	...	...	...	47·92	56 38	47·37	44·83
Cane Garden	...	...	...	49·01	56·25	51·90	46·88
Round Hill	...	...	...	...	60·85	53·07	48·24
Maddens ...	..	...	...	...	...	44·83	35·48
Old Manor...	...	...	...	...	...	...	44·2
Farm ...	...	...	...	...	...	...	46·77
Means of all Stations*	60·90†	56·75	47 98	46·34	56·15	48 31	44·41

*Average 52·16. †For three years.

Assistance in the matter may be gained by consulting Table B 1 which, however, as has been explained, was constructed for a different purpose. Here, the figures are given for each month of the year, and for seven-year periods, in the case of each estate for which two periods at least could be compiled. Taking the periods, where records for more than two are available, in the order of their occurrence, we find: Bush Hill: 50·37, 43·18, 48·94, 43·95 inches; Cane Garden: 51·89 54·34, 48·34 inches; Pinney: 50·21, 52·24, 45·54 inches There is no gradual lessening in the magnitude of the figures that would indicate a diminishing rainfall.

The next suggestion that arises is that the tables should be consulted in order to discover if they agree in presenting any interesting positive fact in relation to the rainfall. When this is done, it is almost immediately rendered evident that the rainfall of Nevis has been less during the last few years, up to the end of 1908. The fact is especially well brought forward in Table B 1, in the case of all stations.

Another reference to the tables will show that the occurrence of such a period of low rainfall is not abnormal, and that there is no reason to apprehend that the conditions which have given rise to it are of a permanent nature. Table A 1 shows that similar circumstances prevailed at a time which fell about the period 1884 to 1893, and this fact is upheld by the figures for 1888-94 in Table B 1, in the case of every station. It would appear, then, that this latest period of low rainfall is only one of a constantly recurring series. The records do not go back sufficiently far to give evidence as to whether this recurrence takes place at regular intervals.

The following table (A 2) gives the five-year means, as far as they are available, for Antigua: these will be shortly treated, in the way that has been employed for the records from Nevis. Here again, there is no evidence of a gradual diminution in the rainfall throughout a number of years, nor does it exist in the figures given for seven-year periods (Table B 2). Both the tables also lead to the same additional conclusions as were arrived at in the case of Nevis, namely: (1) that the rainfall has been smaller during the last few years (to 1908); and (2) that a similar state of affairs existed during a period falling between the years 1884-93. In the latter connexion, it seems significant that the inference may be drawn from the figures for six out of the seven stations at which they were available, for seven-year periods, those for Betty's Hope forming the exception. It is of further interest to record that the same facts are supported by the figures contained in a table, not given here, in which are presented the averages for quinquennial periods for all stations in Antigua.

TABLE A 2. Antigua. Five-Year Periods.

Estate.	1888-93.	1894-8.	1899-1903.	1904-8.
North Sound	...	50·30	46·67	43·17
Betty's Hope	45·58	43·32	43·02	43·38
The Garden	...	...	50·30	..
The Cotton	...	41·69	40·01	34·70
Green Castle	52·66	57·51	54·35	45·98
Montpelier	...	42·61	43·32	35·83
Bendals	53·08	55·79	50·98	42·60
The Diamond	50·97	52·70	...	47·76
Pares	...	...	46·19	43·48
Cochranes	...	...	42·82	...
Means of all Stations*	50·57	49·13	46·41	42·11
Means : Complete records ..	50·41	52·21	49·45	43·99

*Average 47·05.

This conformity in the conclusions, in the matters treated, that may be drawn from a consideration of the rainfall records of Nevis and Antigua bears out the supposition that the precipitation in these two islands is, for periods of years, regulated in its quantity by the same natural conditions. It may be further supposed that this is true of a larger area than the one which includes those islands; records to support this are not, however, to hand at present.

As no gradual diminution in rainfall has been proved to exist, it is naturally impossible to discuss what part the precipitation during the different months of the year may have had in producing that result. There are, however, other interesting questions which merit consideration, and an account of these will now be given.

The fact of the existence of a recent period, during which a noticeably smaller precipitation has taken place, having been proved, it remains to find out what part the different portions of the year have had in contributing to the general result. As has been stated, tables have been constructed which show the means for seven years, for each station, for every month of the year, together with the means, in the same way, for the whole period under consideration; while, in addition, the mean rainfall during the last seven-year period has been compared, on the basis of a percentage, with the average of the periods

during the whole time under discussion. The table containing the statistics for Nevis, on these bases, follows. In dealing with the results, the last column has been consulted in order to find, for each month, the number of estates on which the rainfall during the last period has been above, equal to, or near (within 5 per cent. of) the average for the whole period for which figures are given. In two months, May and December, this has been the case at the maximum number of stations—five. March and September are next in order, with four; the numbers for the other months are insignificant. Apart from theoretical considerations, the conclusion that is of practical value* can be immediately deduced: that, during a period of diminished rainfall, in Nevis, the months that can be depended upon to give their quota of the normal supply are March, May, September and December, while it is the lessened rainfall of the other months that contributes to the general result.

TABLE B 1. NEVIS. SEVEN-YEAR PERIODS.

BUSH HILL.

Month.	Seven-year averages. 1902-8.	1895-1901.	1888-94.	1881-87.	Average of periods.	Percentage (1902-8) below average of periods.
January	2·38	3·35	2·61	3·44	2·95	19
February	1 60	1·94	1·82	2·39	1·94	18
March	2·70	2·02	1·42	2·20	2·08	(above)
April	1·89	1·48	3·07	2 99	2·36	20
May	4·54	5·22	3·02	3·60	3·59	(above)
June	4·24	4·18	4·50	4·03	4·24	(equal)
July	2·71	5·67	4·06	4·43	4·22	36
August	3·88	4·34	4·39	6·07	4·67	17
September ..	6·29	7·21	4·99	6·17	6·16	(above)
October	3·38	4 90	5·01	4 38	4·42	1
November	5·25	7·24	5·39	7·04	6·23	16
December	5·08	3·38	2·77	3·60	3·71	(above)
Average year ...	43·95	48·94	43·18	50·37	46·61	6

* This may have a distinct bearing on the advisability of the early planting of cotton—a procedure that is desirable on general grounds. [A. H. K.]

CANE GARDEN.

Month.	Seven-year averages. 1902-8.	1895-1901.	1888-1894.	Average of periods.	Percentage (1902-8) below average of periods.
January ..	2·76	3·23	3·27	3·09	11
February ..	2·08	2·26	2·44	2·26	8
March ...	3·00	2·03	1·88	2·30	(above)
April ..	2·06	1·73	3·99	2·60	21
May	4·73	3·88	3·72	4·11	(above)
June	4·54	4·81	5·50	4·95	8
July	3·24	6·63	4·72	4·86	33
August ..	4·37	4·81	5·18	4·79	9
September ..	7·38	8·02	5·72	7·04	(above)
October .	4·03	5·16	6·20	5·13	21
November	5·41	8·48	6·02	6·61	19
December .	4·73	3·29	3·31	3·78	(above)
Average year	48·34	54·34	51·89	51·53	7

MADDENS.

Month.	Seven-year averages. 1902-8.	1895-1901.	Average of periods.	Percentage (1902-8) below average of periods.
January	1·96	3·59	2·77	29
February	1·06	2·09	1·57	32
March	1·66	1·95	1·81	8
April	1·77	2·20	1·99	11
May	4·44	4·45	4·44	(equal
June	3·10	4·46	3·77	18
July	2·66	4·63	3·65	27
August	3·10	4·72	3·91	21
September ...	6·29	8·49	7·39	15
October	4·49	4·86	4·67	4
November ...	4·35	7·69	6·02	28
December ..	3·28	3·25	3·26	(above)
Average year ..	39·45	52·39	45·20	13

PINNEYS.

Month.	Seven-year averages. 1902-8.	1895-1901.	1888-1894.	Average of periods.	Percentage (1902-8) below average of periods.
January ..	2·53	2·83	3·15	2·84	11
February ...	1·78	1·85	2·63	2·09	15
March ...	2·79	1·98	1·75	2·17	(above)
April	1·99	2·17	3·68	2·61	24
May	4·02	3·06	3·49	3·53	(above)
June	4·12	5·00	5·36	4·83	15
July	3·12	5·79	4·92	4·61	32
August ..	4·10	4·90	5·22	4·74	14
September ...	6·99	7·36	5·28	6·54	(above)
October ...	4·43	6·05	5·85	5·44	19
November ...	4·83	7·79	5·69	6·11	21
December ...	1·97	3·15	3·29	3·91	(above)
Average year	45·54	52·24	50·21	49·33	8

ROUND HILL.

Month.	Seven-year averages. 1902-8.	1895-1901.	Average of periods.	Percentage (1902-8) below average of periods.
January	2·27	2·82	2·55	11
February	1·17	1·44	1·31	11
March	3·52	2·49	3·00	(above)
April	2·80	1·82	2·31	(above
May	4·79	4·81	4·80	(equal)
June	4·95	5·19	5·07	2
July	3·16	6·05	4·60	31
August	4·48	4·84	4·66	4
September ...	8·28	8·93	8·61	4
October	4·76	6·19	5·48	13
November ..	5·17	9·17	7·17	28
December ...	5·35	3·37	4·36	(above)
Average year ..	50·71	57·13	53·91	6

The following table contains the results, similarly, for Antigua. The same method as that which has been employed for dealing with those of Nevis shows that the most dependable months for rainfall during a series of dry years are March, April, September, November and December. The three last-mentioned months have almost reached, or passed, the normal rainfall at the maximum number of stations—seven; April at six; and March at five.

TABLE B 2.—ANTIGUA. SEVEN-YEAR PERIODS.
NORTH SOUND.

Month.	Seven-year averages.			Average of periods*	Percentage (1902-8) below average of periods.
	1902-8.	1895-01.	1888-94*		
January ...	2·25	2·66	2·73	2·53	11
February ...	1·18	1·27	1·74	1·38	15
March ...	1·92	2·02	1·51	1·83	(above)
April... ...	3·01	1·36	4·14	2·77	(above)
May	2·73	4·77	4·37	3·94	31
June	3·40	3·03	1·13	3·49	3
July	3·02	5·62	3·48	4·07	26
August ...	4·66	4·71	4·25	4·56	(above)
September ...	7·86	6·63	6·08	6·89	(above)
October ..	4·51	6·63	6·53	5·86	23
November ...	6·27	6·79	3 82	5·72	(above)
December ...	5·07	3·76	3·49	4·14	(above)
Average year	45·88	48·53	46·27	46·92	2

* 1891 missing.

BETTY'S HOPE.

Month.	Seven-year averages.			Average of periods.	Percentage (1902-8) below average of periods.
	1902-8.	1895-1901.	1888-94.		
January ...	2·18	2·71	2·91	2·63	16
February ..	1·36	1·07	1·96	1·46	6
March ...	1·56	1·58	1·40	1·51	(above)
April... ...	3·18	0·98	3·77	2·64	(above)
May	3·23	4·17	2·77	3·39	4
June	2·91	2·87	4·04	3·26	10
July	3·10	5·10	4·79	4·33	28
August ...	4·60	4·32	3·90	4·27	(above)
September ..	7·17	5·83	5·69	6·23	(above)
October ...	4·61	5·17	5·37	5·05	8
November ...	6·13	5·68	3·96	5·25	(above)
December ...	4·22	3·45	3·65	3·77	(above)
Average year	44·25	43·03	44·21	43·83	(above)

THE COTTON.

Month.	Seven-year averages.			Average of periods*	Percentage (1902-8) below average of periods.
	1902-8.	1895-1901.	1888-94*		
January ...	1·26	2·10	2·49	1·92	34
February ...	0·74	0·98	1·87	1·16	36
March ...	1·37	2·25	1·19	1·62	15
April... ...	2·16	1·22	4·18	2·43	11
May	2·96	3·62	3·18	3·25	9
June	2·62	2·98	3·73	3·08	15
July	2·34	4·03	2·64	3·02	23
August ..	3·63	4·33	3·96	3·98	9
September ...	6·09	5·75	5·26	5·72	(above)
October ...	4·03	4·90	4·89	4·63	11
November ...	5·84	5·63	2·80	4·88	(above)
December ...	3·73	3·11	3·60	3·47	(above)
Average year	36 86	41·01	39·39	39·09	6

* 1891 missing.

GREEN CASTLE.

Month.	Seven-year averages.			Average of periods.	Percentage (1902-8) below average of periods.
	1902-8.	1895-1901.	1888-94.		
January ...	2·41	3·39	3·00	2·93	18
February ...	1·32	1·49	2·13	1·62	19
March ...	2·37	2·22	2·21	2·27	(above)
April... ...	3·69	1·62	3·42	2·89	(above)
May	3·52	3·98	3·53	3·68	4
June	4·45	3·88	5·32	4·51	1
July	3·22	6·94	4·73	4·97	35
August ...	4·13	5·66	3·95	4·61	10
September ...	8·45	8 04	7·02	7·88	(above)
October ..	3·80	6·07	6·56	5·42	30
November ...	6·75	8·31	5·57	6·95	3
December ..	5·40	4·64	4·56	4·88	(above)
Average year	49·51	56·28	53·66	52·62	6

MONTPELIER.

Month.	Seven-year averages.			Average of periods.	Percentage (1902-8) below average of periods.
	1902-8.	1895-19 1.	1888-94.		
January ...	1·95	2·72	2·36	2·34	13
February ...	1·10	1·27	1·38	1·25	15
March ...	1·72	1·75	1·40	1·58	(above)
April... ..	2·75	1·03	2·99	2·26	(above)
May	2·92	3·56	2·36	2·95	1
June	2·54	3·68	3·98	3·40	34
July	2·22	5·97	4·62	4·27	48
August ...	3·94	4·48	3·38	3·93	(equal)
September ...	5·90	6·09	5·06	5·68	(above)
October ...	3·76	5·94	3·75	4·48	19
November ..	5·65	5·85	2·69	4·73	(above)
December ...	3·66	3·68	3·35	3·56	(above)
Average year	38·12	44·59	37·64	40·12	5

BENDALS.

Month.	Seven-year averages.			Average of periods.	Percentage (1902-8) below average of periods.
	1902-8.	1895-1901.	1888-94.		
January ...	2·21	3·34	3·15	2·90	24
February ...	1·20	1 54	2 64	1·79	33
March ...	2·04	2·36	2·57	2·33	12
April... ...	3·15	1·64	3·56	2·79	(above)
May	3·21	3·75	3·74	3·57	10
June	4·05	3·39	5 37	4·27	5
July	3·15	6·81	4·97	4·97	37
August ...	4·01	5·32	4·66	4·66	14
September ...	7·22	7·73	6·33	7·15	(above)
October ...	3·82	6·31	6·69	5·61	32
November ...	6·57	7·64	5·07	6·43	(above)
December ...	4·83	4·78	4·07	4·56	(above)
Average year	45·51	54·60	52·84	50·98	11

THE DIAMOND.

Month.	Seven-year averages.			Average of periods*	Percentage (1902-8) below average of periods.
	1902-8.	1895-1900.*	1888-94.		
January ...	2·35	3·12	3·36	2·94	20
February ...	1·34	1·67	2·21	1·74	23
March ...	1·98	2·46	1·58	1·98	(equal)
April... ...	3·69	1·85	3·48	3·06	(above)
May	3·55	5·61	3·48	4·14	14
June	3·39	3·51	4·67	3·82	11
July	3·28	6·82	5·10	5·00	34
August ..	4·84	5·52	4·48	4·92	2
September .	8·00	7·42	6·14	7·21	(above)
October ...	4·29	5·26	6 02	5·19	17
November ...	6·68	6·94	4·93	6·14	(above)
December ...	5·12	4·06	3·90	4·23	(above)
Average year	48·44	54·22	48·82	50·31	4

*1901 missing.

A comparison of the results for Nevis with those of Antigua shows that, although the months during which an approach to the normal rainfall may be expected, in a series of dry years, are not quite the same in the different islands, yet the conditions are similar if the question is considered from the point of view of periods of the year. Thus, a reference to the tables, and to what has just been said, shows that the rainfall of both islands is least likely to decrease at the equinoxes, and at the end of the year. Thus, the slight disparity in the matter of months is probably due to the fact of taking the results over short periods of the year, so that the effect of local conditions is allowed to show itself.

The conclusions that have been reached may be summarized as follows:—

(1) That the rainfall of Antigua and Nevis is not gradually diminishing.

(2) That the precipitation has been smaller than the normal amount, in both islands, during the last few years.

(3) That periods during which this takes place recur at intervals, the last one having been in or near the years 1884-93, so that the condition is not abnormal.

(4) That the general conclusion may be drawn, from the three foregoing statements, that there are periods of years of diminished rainfall, over large areas, that are intermittent in their occurrence. There is no evidence to show whether these happen regularly or not.

(5) That, for both islands, during a period of years in which the rainfall is deficient, the times at which the precipitation may be relied upon to be nearest to the normal amount occur at or near the equinoxes and at the end of the year.

(6) That, on the contrary, during such a period, the months whose rainfall suffers the greatest diminution are those which are most remote from the equinoxes, with the exception of those that immediately precede the close of the year. This, in effect, means that a period of diminished rainfall owes its existence mainly to abnormally small precipitation during the beginning and middle of the year. This does not preclude the possibility of assistance being given, in attaining the general result, by the fact that the rainfall of the other months has remained near the average for several years.

(7) That all the above considerations help to indicate that the conditions which regulate changes in the rainfall for periods of several years have a wide area of operation.

COURSES OF READING AND EXAMINATIONS IN PRACTICAL AGRICULTURE.

In connexion with the Courses of Reading and Examinations in Practical Agriculture, instituted by the Imperial Department of Agriculture for the West Indies, three examinations have already been held. These consisted of examinations in the Preliminary stage, conducted on February 13 and 15, and October 11, 1909; and one in the Intermediate stage, on November 1 and 2, 1909.

At the first Preliminary Examination, fourteen candidates presented themselves. Of these, two passed in the first class, four in the second, and three in the third class, while five failed to satisfy the examiners. In the second Preliminary Examination, there were twenty candidates, of whom five passed in the first class, the same number in the second and third classes, and five failed. Twelve candidates took the only Intermediate Examination that has been held so far, when the certificates gained were as follows: first class, five; second class, three; and third class, two. The remaining two candidates will be required to pass satisfactory examinations in certain parts of the syllabus before the certificate can be granted to them.

It is interesting to note that the number of islands in which the first Preliminary Examination was held was two—Antigua, and St. Kitts—while, in the second, it had extended to seven: these were Antigua, Barbados, Dominica, Grenada, St. Kitts, St. Lucia, and St. Vincent. The Intermediate Examination was held in six islands—those in the list just given, with the exception of St. Vincent.

The experience that has been gained, in organizing and conducting the examinations, has led to the adoption of several modifications of the original scheme, though it remains the same in its general aspect. One of these changes has been to arrange for the holding of yearly, instead of half-yearly, examinations. Another is in the direction of making additions, to some extent, to the syllabus of the Reading Courses. As a result of this, a leaflet (No. 1, New Series, February, 1910.) has recently been issued by the Department for the purpose of presenting the syllabus as it now stands, after modification. As the matter is of general interest, and for purposes of record, the substance of this leaflet is reproduced here.

READING COURSES AND EXAMINATIONS IN PRACTICAL AGRICULTURE.

Reading Courses have been established, under the direction of the Imperial Department of Agriculture, for the purpose of enabling overseers on estates, and others engaged in the practice of Agriculture, to acquire, from reading, knowledge that they can apply in connexion with their practical work.

Examinations will be held periodically at various centres in the West Indies, at which times, persons who have previous-

ly been registered as students in the Reading Courses may become candidates.

Examinations will be held during October and November each year. There are three examinations in the series:—Preliminary, Intermediate and Final. Each examination consists of two parts, written and oral. The oral part is intended to bring out the candidate's knowledge in its practical application to his work and, in the Intermediate and Final Examinations, this part will be conducted by representative planters at each centre, who may from time to time be willing to assist the Department in this service.

The Preliminary Examination requires a general all-round knowledge and education, such as might be expected of an intelligent young man about to begin his career in the planting profession. Candidates who have passed the Cambridge Senior Local Examination in Agricultural Science, or the Examinations in Agricultural Science at Harrison College, Barbados, or who are in possession of any other certificate which may be deemed by the Imperial Commissioner of Agriculture to be an equivalent, will be excused from taking the Preliminary Examination.

The Intermediate Examination is of a standard to require such knowledge of planting work and the general principles of Agriculture as might be expected of an intelligent overseer of a few years' experience.

The Final Examination requires such knowledge as might be expected from a man capable of being entrusted with the management of an estate.

Persons who wish to take the examinations must be registered as students in the Reading Courses outlined by the Imperial Department of Agriculture, and the examinations must be taken in the order named.

Registration in the Reading Courses and the payment of the fee entitle students to certain publications of the Imperial Department of Agriculture, which are recommended for reading; students are also entitled to sit for the examinations, provided they give notice of their intention to do so in the manner required. Notices will be sent out to all the students in the Reading Courses prior to each examination, with forms to be filled in, signed and returned, on which students may signify their intention to sit for certain examinations.

For all information required in regard to Reading Courses and Examinations, application should be made to the Senior Officer of the local Department of Agriculture in each island.

Candidates who are successful in passing the prescribed examinations will be awarded certificates by the Imperial Commissioner of Agriculture. It is intended that the possession of the three certificates, Preliminary, Intermediate and Final, or in the special circumstances cited above, of the Intermediate and Final, shall be a guarantee of a sound general knowledge of the fundamental principles underlying the practice of Agriculture, and also of a practical knowledge of at least two crops, and their products, such as Sugar, Cacao

Cotton, Limes, Rice and Bananas. Provision Crops, including Sweet Potatos, Yams, Corn, Eddos, and the like, may be allowed by arrangement to take the place in these examinations of one of the principal crops in those districts where only one principal crop is usually grown.

SYLLABUS.

Reading Courses Preparatory to the Preliminary Examination.

An elementary knowledge of the following subjects and topics will be expected from candidates in the Preliminary Examination :—

The atmosphere and the gases composing it. Water and its properties. The chemical and physical properties of sand, clay, chalk and humus. The classification of soils. The functions of plant food and water. Drainage of soil. The construction and use of one form of plough, of subsoiler, and of cultivator. Tillage and its effects. The preparation and properties and chief constituents of farmyard manure. The properties and uses of the common artificial manures and of lime. Green dressings and organic manures. Micro-organisms in soil and in relation to leguminous plants.

Seeds: their structure and germination. The naked-eye structure, and the outlines of the microscopic structure of the root, stem, leaf, flower and fruit of a plant.

Assimilation, transpiration, and respiration in plants. Plant food. The absorption and movement of water in plants.

The propagation of plants by cuttings, by grafting and by budding. Pollination and fertilization. Structure and Functions of Farm Animals.

The following references indicate the reading which will furnish the required information in regard to the foregoing points:—

Fream's *Elements of Agriculture*, pp. 1-110 and 334-86.
Duggar's *Agriculture for Southern Schools.*
Cousins, *Chemistry of the Garden.*
Nature Teaching. (I.D.A.)
Lectures to Sugar Planters, lectures 1-4. (I.D.A.)

Reading Courses Preparatory to the Intermediate Examination.

A more thorough knowledge of the general subjects given under the previous heading will be required in the Intermediate Examination and, in addition, the candidate must be familiar with fungoid diseases and insect pests of agricultural crops.

The general characters of fungi. Fungoid diseases on plants. General treatment of fungoid diseases.

General life-history of insects. The principal orders of insects. The relation of insects to plants. The general treatment of insect pests.

Fream's *Elements of Agriculture*, pp. 312-33.

Fletcher's *Soils*.

Lectures to Sugar Planters. (I.D.A.)

PAMPHLETS.

No 5, 'General Treatment of Insect Pests'.
" 7. 'Scale Insects of the Lesser Antilles', Part I.
" 22, 'Scale Insects of the Lesser Antilles', Part II.
" 17, 'General Treatment of Fungoid Pests.'
" 29. 'Lectures on Diseases of the Sugar-cane.'

WEST INDIAN BULLETIN.

Root Disease of the Sugar-cane, by F. A. Stockdale, B.A., F.L.S.

Insect Pests affecting Sugar-cane, by H. A. Ballou, B.Sc.

In addition, students should read the articles in the *Agricultural News* on the Orders of Insects, in Vols. VI and VII; the series on the Natural History of Insects in Vol. VIII, and those entitled 'Fungus Notes'.

CROP SUBJECTS.

In addition to the general agriculture on the lines indicated above, two crop subjects must be prepared for the Intermediate Examination. The selection of the crops to be taken will be optional, but they must be crops with which the candidate has had practical experience.

SUGAR-CANE CULTIVATION. The preparation and care of the soil, planting, manuring, tending and reaping the crop. The principal varieties of sugar-cane and their characteristics. The principal fungoid diseases and insect pests of the sugar-cane and the methods of controlling them.

SUGAR MANUFACTURE, MODERN FACTORY METHODS. Students who elect to be examined in this branch will be expected to be familiar with the general principles underlying the factory method of sugar manufacture, such as structure and the working of the triple effect, the vacuum pan, and the process of maceration, etc.

SUGAR MANUFACTURE, MUSCOVADO METHOD. A good knowledge of the general principles in this branch will be expected of students who sit for it. This will include a knowledge of tempering lime juice, boiling sugar, etc., etc., the use of tayches, and steam-heated pans.

RUM MANUFACTURE. In this branch, students for the examination will be expected to have some knowledge of the processes of fermentation and distillation, the life-history of yeasts, the structure of stills, etc.

Noel Deerr's *Sugar and the Sugar-cane.*

Watts's *Introductory Manual for Sugar-Growers.*

Lectures to Sugar Planters. (I.D.A.)

West Indian Bulletin. Papers relating to the sugar industry.

Pamphlets dealing with Experiments with Sugar-canes in Barbados and the Leeward Islands.

Annual Reports of the Botanic and Experiment Stations.

Candidates who take the examination on the Sugar Industry may be passed if successful in the first part—Sugar-cane Cultivation; but they may, if they so choose, take any of the other parts under this heading. They will be allowed to take, *in addition* to Sugar-cane Cultivation, either Sugar Manufacture, Factory Methods, or Sugar Manufacture, Muscovado Method, or Rum Manufacture; but will not be allowed to take two of them at one examination, except that the parts relating to Muscovado Sugar and Rum may be taken if so desired.

The subject in which the candidate is successful in passing will be mentioned on the certificate.

COTTON. Preparation of the soil; planting and tending the growing crops. A knowledge of the principal insects and fungoid pests of cotton and the means used in controlling them. Picking cotton. The selection of cotton seed and its preparation for sowing. An elementary knowledge of the qualities of cotton lint and the manner of ascertaining them. The uses of cotton seed.

Pamphlet No. 45, 'A B C of Cotton Planting.'

Pamphlet No. 60, 'Cotton Gins.'

West Indian Bulletin.

Annual Reports of the Botanic and Experiment Stations.

LIMES. The planting and tending of lime orchards. The chief pests attacking limes, and the methods of controlling them. Gathering the crop. Crushing the fruit. The methods of dealing with lime juice. The preparation of concentrated juice and citrate of lime. The preparation of essential oil of limes. The preparation and packing of lime fruit for shipment.

Pamphlet No. 53, 'A B C of Lime Cultivation.'

Botanic Station Reports.

West Indian Bulletin.

CACAO. The planting and tending of cacao orchards. The chief pests attacking cacao, and the methods of controlling them. The gathering of the crop. The fermentation and preparation of the cacao beans for market.

Hart's *Cacao*.

Wright's *Cacao, its Botany, Cultivation, Chemistry and Diseases*.

Pamphlet No. 58, 'Insect Pests of Cacao.'

Pamphlet No. 61, 'The Grafting of Cacao.'

Reports on the Experiments with Cacao at Dominica and Grenada.

BANANAS. The planting and tending of banana fields. The chief pests attacking bananas and the methods of controlling them. The gathering, handling, packing and shipping of the fruit.

'The Banana Industry in Jamaica', *West Indian Bulletin*, Vol. III, No. 2.

RICE. Cultivation and preparation.

'Rice-Growing in British Guiana', *West Indian Bulletin*, Vol. II, No. 4.

PROVISION CROPS.

Nicholls' *Tropical Agriculture*. Those portions dealing with Maize, Guinea corn, Cassava, Arrowroot, Yam, Potato, Tania.

FINAL EXAMINATION.

The principles of agriculture as set out in the syllabus for Preliminary and Intermediate examinations, treated more fully, and including :—

The origin, formation and composition of soils. The biology of soils. The implements, methods and effects of tillage. Manures and manuring. Farmyard manures. Green dressings. Liming, etc. Rotation of crops. Hay-making. Ensilage. Improvement of plants by artificial selection and hybridization. The management and care of farm animals. Special crops: any two of those mentioned in the intermediate syllabus, but treated more fully.

Candidates must show an accurate knowledge of estate book-keeping, of the cost of performing various operations in husbandry, together with a knowledge of the principal facts governing estate expenditure. They must be familiar with the management of labourers, with the apportionment of, and payment for, work done. They will be required to answer questions concerning the general fundamental principles of estate management, including the management of land, simple

land mensuration, crops, labourers, and farm animals, and to show an elementary knowledge concerning the management and care of buildings and implements generally.

Candidates will be expected to be familiar with, and capable of critically examining, the work and results of the local Experiment Stations and the reports and papers emanating therefrom.

Reading :—

All books previously mentioned.

Hall. *The Soil.*

„ *Fertilizers and Manures.*

Lipman. *Bacteria in Relation to Country Life.*

King. *Physics of Agriculture.*

General List of Books Recommended for Use in Connexion with These Courses.

[It is not expected that any student should procure *all* the books listed. A careful choice should be made of those books likely to be of greatest value to the individual student. In making this choice, the assistance of the Officers of the local Department of Agriculture should be sought.]

'Elements of Agriculture', by W. Fream (Published by Murray), 2*s.* 6*d.*

'Catechism of Agricultural Chemistry', by Johnson (Published by Blackwood & Sons), 1*s.*

'Chemistry of the Garden', by H. H. Cousins (Published by Macmillan), 1*s.*

The Soil', by A. D. Hall (Published by J. Murray), 3*s.* 6*d.*

'Nature Teaching', Imperial Department of Agriculture, 2*s.* 6*d.*

Lectures to Sugar Planters', Imperial Department of Agriculture, 1*s.*

'Sugar and the Sugar-cane', by Noel Deerr (Published by N. Rodger, Altrincham, Manchester), 7*s.* 6*d.*

'Introductory Manual for Sugar-Growers', by Dr. F. Watts (Published by Longman's, Green & Co.).

'Cacao', by J. H. Hart (Published by Davidson & Todd, Trinidad), 3*s.*

'Cacao, its Botany, Cultivation, Chemistry, and Diseases', by Herbert Wright (Published by Ferguson, Colombo and London), 7*s.* 6*d.*

'Tropical Agriculture', by Dr. H. A. A. Nicholls (Published by Macmillan), 6*s.*

'Agriculture for Southern Schools', by Duggar (Published by Macmillan), 4*s.*

'Southern Agriculture', by Earle (Published by Macmillan).

'Principles of Plant Culture', by Goff (Published by Author).

'Fertilizers and Manures', by Hall (Published by John Murray), 5*s.*

'Soils', by Fletcher (Published by Constable).

'Cane Sugar and its Manufacture', by H. C. P. Geerligs (Published by Norman Rodger).

'Bacteria in Relation to Country Life', by Lipman (Published by Macmillan).

'Physics of Agriculture', by King.

Publications of the Imperial Department of Agriculture :—

PAMPHLETS.

No. 5, 'General Treatment of Insect Pests', *4d.*
No. 7, 'Scale Insects of the Lesser Antilles', Part I, *4d.*
No. 22, ,, ,, Part II, *4d.*
No. 17, 'General Treatment of Fungoid Pests', *4d.*
No. 29, 'Lectures on the Diseases of the Sugar-cane', *4d.*
No. 45, 'A B C of Cotton Planting', *6d.*
No. 53, 'A B C of Lime Cultivation', *4d.*
No. 54, 'Fungus diseases of Cacao and Sanitation of Cacao Orchards', *4d.*
No. 58, 'Insect Pests of Cacao', *4d.*
No. 61, 'Grafting of Cacao', *4d.*

Candidates can also obtain very useful information from publications of the Imperial Department of Agriculture other than those specially mentioned in the above list. It is recommended that the *Agricultural News*, the *West Indian Bulletin*, together with Reports on local Experiment Stations and pamphlets, should be regularly consulted.

WEST INDIAN BULLETIN.

The Flower-bud Maggot of Cotton, by H A. Ballou, Vol. IX, p. 1.

Scarabee of the Sweet Potato, by H. A Ballou, Vol. X, p. 180.

Treatment of Cotton Pests in the West Indies, by H. A. Ballou, Vol. IX, p. 235.

Root Disease of the Sugar-cane, by F. A. Stockdale, Vol. IX, p. 103.

Insect Pests affecting Sugar-cane, by H. A. Ballou, Vol VI, p. 37.

Fungus Diseases of Cotton, by L. Lewton-Brain, Vol. VI, p. 117.

AGRICULTURAL NEWS.

Natural History of Insects.' 'Orders of Insects.'

Articles on the Life-History of the Fungi', Vol. VIII, Nos. 190–2.

BOTANIC AND EXPERIMENT STATION REPORTS.

Pages 197-292 issued March 9, 1910.

THE AGRICULTURAL CONFERENCE IN ANTIGUA, 1910.

The following is an account of the proceedings at the Agricultural Conference that was held in Antigua from January 8 to 15, 1910. The holding of this Conference arose from the fact that, through the instrumentality of the Imperial Commissioner of Agriculture for the West Indies, Dr. F. Watts, C.M.G., arrangements were made for a party of representative planters, and others interested in the sugar industry in Barbados, to visit Antigua for the purpose of inspecting the central factories at Gunthorpes and Bendals, the newly introduced methods of cultivating sugar-cane by means of implements, and the sugar-works that had been fitted with apparatus for making muscovado sugar in steam-heated pans. At the same time, the object of seeing as much as possible of matters of agricultural interest was kept in view. The proceedings became of the nature of a conference, because it was decided to take advantage of the presence, in Antigua, of the visitors from Barbados, to hold a series of meetings, which representatives of the Agricultural Societies of Antigua and St. Kitts should be invited to attend—an invitation that was accepted willingly. For the more general information, the following account is indebted largely to the report of the proceedings that was made by the members of the Barbados Agricultural Society and others from Barbados who attended the Conference, and to a report on the same subject by Mr. H. A. Tempany, B.Sc., Government Chemist and Superintendent of Agriculture for the Leeward Islands.

On Wednesday, January 5, the members of the expedition embarked on board the SS. 'Dahome' *en route* for Antigua, via St. Lucia and Dominica. St. Lucia was reached at 7 a.m.

on the morning of the 6th. On their arrival, the members were met by Mr. J. C. Moore, the Agricultural Superintendent. Directly afterwards, the Hon. E. J. Cameron, C.M.G., the Administrator of St. Lucia, met the Commissioner of Agriculture and conferred with him as to the programme for the day, so as to decide, as far as possible, the arrangements for carrying it out. The members first visited the Botanic Station, which is situated to the east of the harbour, on the site of what was once a swamp. This swamp has been reclaimed by depositing on it the dredgings from the harbour, and has been planted up with various economic plants and ornamental trees, etc. It is now a prettily laid out garden where the inhabitants of the island and visitors can spend an interesting and instructive time. After visiting the gardens, the members of the expedition embarked on board the 'Midge', a Government launch, which had been placed at their disposal by Mr. Cameron, for the Cul-de-Sac sugar factory. This factory is at the mouth of a valley of that name, on the western side of the island, about half an hour's steam from Castries. Messrs. G. Graf and J. Devoeux, two of the Directors of the Cul-de-Sac factory, accompanied the members, and they were met on the jetty on their arrival by the Hon. E. G. Bennett, K.C., the Managing Director, and Mr. L. Springer, the manager of the estate. The factory, which is situated on the coast, was erected in 1874. At that time, the diffusion process was installed, the evaporation of the cane juice and the maceration water being carried on by means of a triple effet and vacuum pans. Subsequently, mainly owing to the cost of the fuel necessary for concentrating the juice, the diffusion process was abandoned and a 3-roller mill substituted. The triple effet, which had proved too small, was replaced by a Yaryan quadruple evaporator, the steam being generated by six multitubular and one Babcock-Wilcox water tube boilers. After the factory had been inspected, the party was taken along the railway line on mule cars to inspect the cultivation. Excellent sugar-canes, of which there were several varieties, including the Bourbon, were seen on the way. Owing to the natural fertility of the soil and the abundant rainfall, canes of practically all ages up to twentieth ratoons were observed. On the return journey the members were entertained at lunch by Mr. Bennett, and after inspecting the sugar-cane experiment plots of some of the newer seedlings obtained originally from Barbados by the Agricultural Superintendent at St. Lucia, they returned to the factory and then embarked on the 'Midge' and steamed out of the bay to meet the SS. 'Dahome', which through the courtesy of Captain Gorst had come to convey them.

Dominica was reached at daylight on Friday, January 7. Here the party was met by Mr. Jones, the Curator of the Botanic Station, and Mr. Lambert Bell. After an early breakfast on board the ship, the members landed and visited the Government Botanic Garden and Experiment Station, where horses were in waiting to take them to the Agricultural School at Morne Bruce. Having spent a couple of hours in inspecting the building and experiment plots, they returned to

the Botanic Garden. This, including the economic and experiment grounds, comprises 42 acres, situated at the foot of Morne Bruce. It was started some eighteen years ago on an old sugar and cacao estate by the Government, under Mr. Green, who was, however, quickly succeeded by Mr. Jones. It is now one of the prettiest gardens to be found in the West Indies and reflects great credit on Mr. Jones, who has been mainly responsible for laying it out. Here was seen in operation the excellent work which has been such a factor in developing the resources of the island. There were noticed numerous beds of seedling limes, cacao, various varieties of rubber and other economic plants. In addition, cacao plants of the best type of the Forastero variety were being grafted on the hardy Calabacillo, the object being to obtain heavy-bearing trees of the best cacao growing on a variety resistant to fungoid diseases, insect pests and drought. Cacao manurial plots on which experiments with various chemical fertilizers and mulching with fallen leaves and other vegetable material were being carried out, were also observed. These plots were very instructive, as they showed the great advantage to be derived from mulching trees with fallen leaves and other similar organic material. In the afternoon, through the courtesy of Mr. H. A. Frampton, a visit was paid to the Bath lime estate where all the processes, from the extraction of essential oil of limes to the finished product of citrate of lime were seen. From the Bath estate, an excursion was made up the Roseau valley also to inspect fields of limes and cacao. On returning to Roseau the party embarked on the 'Dahome' for Antigua, which was reached on the morning of January 8.

On their arrival at Antigua, the party was met by members of the Reception Committee who had been appointed by the Agricultural and Commercial Society to receive them. That afternoon, the members of the expedition were received by his Excellency the Governor and Lady Sweet-Escott, and afterwards they visited the Botanic Garden and the sugar-cane, cotton, and other plots at the Experiment Station at Skerretts. The Botanic Garden, in spite of the somewhat unsuitable site, is very attractive, and a credit to those responsible for its laying out and upkeep. Messrs. F. R. Shepherd, A. D. C. Adamson, and A. Davis, who had been appointed by the Agricultural Society of St. Kitts to visit Antigua while the visitors from Barbados were there, for the same purpose, viz., that of obtaining information with regard to the working of the central factories at Gunthorpes and Bendals, and the implemental cultivation recently installed on some of the estates, arrived the same afternoon by the R.M.S. 'Esk' from St. Kitts.

After breakfast, on Monday January 10, the members were taken by rail to Gunthorpes central factory, where they were met by Mr. and Mrs. G. Moody Stuart and a number of the local planters, and others. The factory, which is very compactly arranged, is situated in a comparatively wide valley, about 4 miles east of the town of St. John. The canes from the estates from which the supplies are drawn, are brought in on a 2-foot-6-inch gauge railway. On their arrival they are weighed and, in

some instances, dumped, in others thrown, on the carrier which takes them to a 60″ × 30″ 6-roller mill in front of which there is a Krajewski crusher set so as to be practically a first mill, which extracts about 50 per cent. of the juice. The juice, as soon as it is extracted, together with the maceration water which amounts to about 20 per cent. of the juice, is pumped into the liming tanks whence, after being measured and limed, it is passed through a triple juice heater and then on to the settling tanks. From these, it is run into three circular eliminators where the feculent matter not deposited in the settlers, is removed by brushing. It is then passed into the triple effet supply tanks, whence it is taken as needed. From the triple effet, the juice which has been concentrated into syrup is discharged into the tanks which supply the vacuum pans, of which there are two. As soon as the massecuite is struck from the pans, it is cured in the centrifugals. The molasses resulting therefrom is reboiled and run into the malaxeurs, where it is converted into second sugars. This second sugar, after being cured, is melted in tanks and taken into the vacuum pan, as required. The settlings and the scums from the juice in process of manufacture are treated in six filter presses, the cake from the presses being conveyed outside the building by means of a tramway. Two Babcock-Wilcox boilers provide steam for the factory, and an electric light plant has been installed for lighting the building and yard. There is also a small machine shop for effecting the necessary repairs. After inspecting the factory, the members of the expedition were entertained at luncheon by Mrs. Moody Stuart, assisted by the staff. After luncheon they visited the reservoir that had recently been built for storing water for the use of the factory. Thence they went to Fitches Creek, an estate on which implemental cultivation, based on the Louisiana system, is carried out. Owing to recent rains, the land was too wet for the ploughs and cultivators to be used. The members, however, had an opportunity of examining the various implements and having explained to them the uses to which they are put. From Fitches Creek they went to Millars estate, the property of the Hon. J J. Camacho, where they were kindly entertained by Mrs. Camacho.

On the morning of Tuesday, January 11, the members of the expedition first visited Belmont estate, where they were shown over the buildings by the Messrs. Dew, one of whom is the manager and the other the engineer. At this estate, there is installed what is known as the Santa Cruz system of sugar manufacture, owing to its having been first adopted in that island. Under this system, the open battery of tayches is dispensed with, and the juice is cleaned and concentrated after it has left the clarifiers, by means of steam-heated eliminators and Aspinall pans, the megass from the mill going direct to the boilers without being dried. From Belmont, the party proceeded, at the invitation of Mr. A. St. G. Spooner, to Bendals to inspect the factory and cultivation on that estate. At this factory there is only a 3-roller mill and a crusher. Otherwise it is equipped with the evaporators, vacuum pans, etc., usually found in an up-to-date sugar factory, together with a blower for increasing the draft under the boilers, so that green

megass can be easily burnt. After going over the factory and the stock pens where fine imported donkeys (a jack and a jenny), and native bred mules were seen, the members were kindly entertained at luncheon by Mrs. Spooner. After luncheon, they were taken to inspect the cultivation on the estate. Owing, however, to the continuous rains, much of this could not be seen, but it was noticed that most of the lands were heavy clays, difficult to cultivate satisfactorily. From Bendals, the party went to the Blubber Valley estate, where they were met by Mr. T. E. Peters, the proprietor, and Mr. S. Smith, the manager. On this estate the Santa Cruz system of sugar manufacture has also been installed; the steam in this instance, having regard to the size of the estate, is generated by a comparatively large Babcock-Wilcox water tube boiler, fired with green megass; very little fuel is required beyond the megass, only three cords of wood being used to make 160 to 170 tons of sugar, with its resulting molasses. After inspecting the factory, the members were taken up the Christian Valley to view the scenery. On their return they were hospitably entertained by Mr. Peters, at Jolly Hill.

On Wednesday, January 12, the members of the expedition from Barbados and St. Kitts-Nevis met in conference, in the Council Chamber at the Court House, a number of the members of the Agricultural and Commercial Society of Antigua. The members present at the Conference were: Dr. Francis Watts, C.M.G., Imperial Commissioner of Agriculture: from Barbados: Hon. F. J. Clarke, C.M.G., M.A., M.C.P., President of the Barbados Agricultural Society and Speaker of the House of Assembly, Messrs. J. R. Bovell, I.S.O., F.L.S., F.C.S., S. S. Robinson, M.C.P., F. W. Greaves, J.P., E. L. Skeete, B.A., D. G. Simpson, J. Connell and Dr. E. G. Pilgrim; from St. Kitts: Messrs. F. R. Shepherd, A. D. C. Adamson and A. Davis; from Antigua: the Hon. J. F. Foote, the Hon. J. J. Camacho, the Hon. R. Warneford, Messrs. A. St. George Spooner, H. A. Tempany, T. E. Peters, N. Scott Johnson, R. S. D. Goodwin, R. Bryson, E. K. Lane, Joseph T. Dew, Ernest T. Dew, W. Forrest, J. C. Waldron, L. S. Cranstoun, J. D. Harper, W. H. Ledeatt, I. E. Dyett, J. J. Roden, H. J. Hall, A. H. Stamers, Robert Goodwin, C. Griffin, S. B. Smith, Stephen R. Mendes, Robert W. Dobson, L. I. Henzell, W. G. Richardson, G. A. Macandrew, D. N. Rannie and G. Moody Stuart, with Messrs. J. D. Wall and R. H. Malone as Honorary Secretaries.

The Conference was opened by his Excellency the Governor, Sir E. Bickham Sweet-Escott, K.C.M.G., who extended a hearty welcome to the visitors from Barbados on behalf of the several Presidencies of the colony. He said that, before they proceeded to business, he should like to emphasize the distinctly unofficial character of the gathering. He was sure his friends from Barbados would be at one with him in the view that they had no authority from the Barbados Government to discuss matters of common interest, and although he, as Governor, was very glad to be present and welcome them, it did not impart any official character to the proceedings of the Conference itself. If it had not been for the establishment of central factories in Antigua, he questioned whether they would have

thought it worth their while to pay Antigua a visit. No doubt, credit was due to his distinguished predecessor for his share in the establishment of factories in Antigua; but, possibly, more credit was due to his friend Dr. Watts, who by his systematic and persevering work had successfully brought the scheme to a conclusion. He hoped that the visitors would be favourably impressed with all they had seen, and still had to see, and that in their turn, they could construct central factories of their own when they saw the advantages that Antigua had derived from their establishment. He noticed that no less than six subjects were presented for discussion and therefore he would not detain them very long. There was, however, one question to which he would refer in passing, namely, that of reciprocal trade relations between the Dominion of Canada and the West Indies. That it was possible for them to discuss this subject was due primarily to the efforts of Sir Daniel Morris, the late Commissioner of Agriculture, who intervened at a most opportune moment and represented to the Imperial Government the urgent need of trade relations between the Dominion of Canada and the West Indies being placed on a permanent basis. The question of trade relations was not one of recent growth; twenty years ago it came up for discussion, but at that time there was no Imperial Minister to bring it to a successful issue. With regard to the colony of Antigua, he observed that in 1905, a strong resolution was passed by the Legislative Council of the colony urging closer relations between Canada and the Leeward Islands, and also that at a Conference held at Barbados in January 1908, a Resolution was passed advocating closer trade relations with the Dominion of Canada. He hoped that the result of their deliberations would be so uniform as to strengthen their position when they urged the Royal Commissioners to recommend the adoption of a scheme which, it was hoped, would link still closer the relations between Canada and the West Indies, and establish trade on a secure basis. In addition to trade relations, the Royal Commission would no doubt consider the question of better telegraphic and steamship communication, and he was confident that those who were gathered there that day would give those matters the thought and study they demanded. He should be glad to learn that some unanimous conclusion had been arrived at, which he might have the opportunity of placing before the Royal Commission. It was possible for the colony of the Leeward Islands to do what had been done in Barbados, and pass new tariff laws for the purpose of facilitating closer trade relations between the West Indies and Canada, and he hoped that before long such laws would have a place on the Statute-book. It could not be disputed that in a colony like the Leeward Islands, composed of so many Presidencies, the interests of all were not necessarily identical, but he believed it would be found in the long run, that the prosperity of one Presidency made for the prosperity of the whole colony, and that one cannot separate the interests of one Presidency from those of the others. With these remarks, he begged once more to extend, on behalf of the Presidencies of Antigua and St. Kitts-Nevis, a most hearty welcome to their

friends from Barbados, and he expressed the hope that the result of their visit to the island would be the establishment of closer relations of all kinds between the two ancient possessions of the Crown.

Dr. Watts, in replying, wished to express, on behalf of those who accompanied him from Barbados and those who had joined him at Antigua, their cordial thanks for the welcome that had been extended to them by his Excellency. He was glad that his Excellency had taken notice of the fact that they were not an official body, but were purely an unofficial organization for the interchange of thought, which would, he hoped, be of advantage to all present. He thanked his Excellency and the Antigua Reception Committee for the kindness and courtesy they had shown the visitors, and all the planters who had so kindly allowed them to go over their estates and factories. The chief object of their visit was to study the conditions pertaining to the establishment of central factories, and they would be losing an opportunity if they did not come together to calmly deliberate and exchange views on many of the momentous questions which were pressed upon them for solution. In view of the near approach of the Royal Commission appointed to investigate the question of improved trade relations with Canada, it seemed to him that, although they could only express an unofficial opinion, they should take the views of the various sugar-producing islands, particularly those producing muscovado. They would be neglecting an opportunity if they did not come together and exchange views and say how far they agreed or differed in their ideas which they had to put before the Commission. In addition to the question of Canadian reciprocity, there were many other matters which could well be dealt with at a meeting like the one they were attending. They had a full programme ranging over many subjects, the result of the discussion of which would be of advantage to those present, and especially to himself. In conclusion, he once more begged to express, on his own behalf and on behalf of those gentlemen who had accompanied him, their cordial thanks for the extremely helpful and kind manner in which they had been received and were being assisted in the carrying out of their programme.

The Hon. F. J. Clarke, on behalf of the visitors, especially of his friends from Barbados, thanked his Excellency and the people of Antigua for their cordial welcome and the great kindness and hospitality that had been shown them. They had been going over factories and were deep in figures and calculations: they had been visiting cane-fields to see cultivations, and going all about the country, gathering information. At Gunthorpes they had found a well arranged sugar factory, and they had been taken over it by Dr. Watts and Messrs. Moody Stuart and Henzell, who had most carefully explained everything to them.

The Governor then left the meeting and the chair was taken by Dr. Watts, who said the first subject on the programme for discussion was the question of trade relations between Canada and the West Indies. The question had been considered, he believed, by the Agricultural Societies of St. Kitts, Antigua

and Barbados, and he would be glad if the representatives of St. Kitts would put forward their views for discussion, then Antigua, and then Barbados. Afterwards they could make suggestions as to the evidence that should be put before the Commission.

Mr. F. R. Shepherd, the Agricultural Superintendent of St. Kitts, read a memorandum, which he explained had been drawn up by the St. Kitts Agricultural Society to be sent to the various Agricultural Societies in the Leeward Islands, but that it was proposed to prepare a more complete memorandum based on those subjects. The memorandum, which he read, may be summarized as follows:—

After pointing out that the evidence to be laid before the Royal Commission should be as uniform as possible, due allowance being made for the somewhat differing interests of component parts of the colony, it was stated that, on general principles, the colony of St. Kitts-Nevis was in favour of reciprocity, but that reciprocity must mean real reciprocity, and that if they gave the Canadian products a preference in the markets of the Leeward Islands colony, they must have the same, *pari passu*, in theirs. Sugar and its by-products, being their main article of export, must be given a fair market. The present so-called preference, it was pointed out, was purely a myth, and that attention should be drawn to the fact that the Halifax buyers always took the parity of New York on which to base their calculations, and that this was unfair, as it was well known that the parity of New York was almost consistently, and often considerably, below the level of London and Greenock: this disparity was brought about artificially by the large American Trusts to depress the price of the Cuban crop. It was suggested that an average should be struck between London, New York, Liverpool and Greenock. It was also pointed out that the subsidized steamship service between Canada and the West Indies was unsatisfactory, and that improvement in this service was an urgent one and should be made. Further, that parcel post rates should be the same as, or less than, those of the United Kingdom, so that residents in the West Indies might be able to make small cash purchases from the department stores in Canada. Also that the frequent breakdown and the high rates of the telegraphic service were a deterrent to business.

Mr. Tempany followed with a memorandum prepared by the Antigua Agricultural and Commercial Society, in which it was stated that the Society was in favour of the establishment of reciprocal trade relations between Canada and the British West Indies, but that if any preferential treatment was to be given to imported goods from Canada, it should be expected that similar treatment, in the case of sugar and molasses, should be extended to that colony. Further, that the action of the Canadian Government in allowing the refiners to import 20 per cent. of the total imports of sugar from foreign countries at the same tariff rates as applied to British sugars, had nullified the advantage given to

the latter, and had, during the past season, diverted a considerable percentage of the sugar grown in Antigua to other markets. Under the old preferential tariff, British West Indian sugar could be obtained more cheaply than foreign sugars, and so would be in greater demand. At the present time, owing to the total Canadian consumption being not more than 200,000 tons of the 240,000 tons produced by the West Indian colonies, their production was more than sufficient to supply the total demand of Canada: hence with the supply considerably in excess of the demand, the Canadian refiners could only be expected to pay such prices as would ensure their obtaining all the sugar they required at the lowest rates. With the addition of 20 per cent. of the total imports being allowed admission at the British preferential rates, the available supply became so greatly in excess of the demand that the advantage of the preference to British possessions largely disappeared. They were therefore of the opinion that, in the event of preferential tariffs being established in the British West Indies, the option of the refiners to import 20 per cent. of their sugar from foreign countries at preferential rates should be abolished until increased consumption showed that the need for it really existed. During the season 1908, owing to the action of the Canadian Government in extending preferential rates to foreign countries, a considerable decrease in the exports of sugar to Canada had taken place, since a better market was obtainable elsewhere. It was also pointed out that the Canadian refiners had been in the habit of basing their prices on those of the New York market and that this was essentially unfair, as the New York market, owing to the preferential treatment extended to Cuba, is considerably below the world's parity, and that some other basis should be taken, in accord with the market value of the rest of the world. It was shown that the total value of the exports from Canada had increased in recent years, and the opinion was expressed, that these would have been further augmented if there existed in Canada, as in New York, commission houses, where orders for small quantities of different goods could be placed, instead of, as was far more inconvenient, placing orders with a large number of individual firms: also that the value of flour shipped in Canadian bottoms had increased from £11 in 1901 to £1,090 in 1909. The opinion was also expressed that preferential treatment should take the form of raising the existing customs duties against foreign countries, while they remained at their present value for British possessions, with the exception of certain articles on which they thought the duty might advantageously be lowered in favour of the British possessions. A statement was prepared showing the general form these alterations should take. It was considered, too, that the freight rates were somewhat excessive and that, although under the existing contract, sufficient accommodation for exports was provided, nevertheless, in the arranging of the shipments it was frequently experienced that freight was often rejected, on account of the small size of the steamers. With respect to telegraphic communication it was stated that the existing rates were excessive, and that the frequent breaks occurring in the cable caused serious inconveniences. In regard to banking

facilities, it was suggested that the high rates of exchange might well be lowered, and that an increase in banking facilities by the introduction of competition would bé beneficial.

Mr. Bovell explained that, so far, nothing had been done in Barbados. A joint Committee of the Agricultural Society and the Chamber of Commerce had been appointed to consider the matter, and at their first meeting a small committee, of which he was a member, had been appointed to gather information for the replies to the questions contained in the memoranda sent out by the Royal Commission. Unfortunately, however, owing to his absence from the island in Porto Rico, and to other circumstances, those replies had not been compiled. The Secretary of the Agricultural Society had been instructed to call a meeting of the Joint Committee of the Agricultural Society and the Chamber of Commerce, together with the agricultural members of the Committee appointed by his Excellency the Governor, at 2.30 o'clock on the afternoon of the Tuesday before they left. Through some misunderstanding, however, only the agricultural members of the Committee appointed by the Governor were summoned, the result being that nothing definite could be done beyond tentatively answering some of the questions. These answers briefly were as follows:—That the Barbados General Agricultural Society should be represented before the Royal Commission by the President; that the subject of trade relations between Canada and the British West Indies had been considered and a resolution adopted; that the chief exports of the colony to Canada were sugars and molasses. With regard to other articles for which a market might be found, it was suggested that cotton lint, cotton seed products, bananas, sweet potatos and yams could be supplied, and it was pointed out that what was needed to secure a market was a regular weekly service of fast steamers having suitable cold storage accommodation, together with a Trade Commissioner for the whole of the British West Indies, whose duty it would be to foster the sale of West Indian products in Canada. It was pointed out that the increase and decrease of the exports of sugar to Canada in recent years would appear to be determined by the attitude of the Canadian refiners, and that if the refiners gave the West Indies their share of preference, the exports to Canada increased; if the preference was withheld, the exports decreased. The subsidized steamship service between Canada and the West Indies was unsatisfactory. The opinion was also expressed that, from an agricultural point of view, the existing banking facilities in Barbados were satisfactory.

Dr. Watts said that, as in the case of the two Presidencies, the trend of opinion in Barbados was on similar lines; that is, that there should be reciprocal trade relations between Canada and the West Indies, and that steps should be taken to bring them about. The general means seemed to be by leaving existing tariffs in favour of Canada and the British possessions, and raising them against foreign countries. There were one or two matters which might be emphasized by formal resolutions comprising these views.

The following resolutions, proposed and seconded by various members of the Conference, were then passed unanimously:—

1. That in the opinion of this meeting, the concessions granted to the Canadian refiners whereby they are empowered to import, on preferential terms from non-preferential countries, sugar equal to one-fifth of the imports, nullify the benefit of the preferential treatment to the British West Indies; and it is therefore desirable that the Royal Commission should be urged to make strong representations directed towards the repeal of this breach of preferential arrangements.

2. That the prices paid in Canada for muscovado sugar from the British West Indies are below the world's parity of prices and show no evidence of preferential treatment.

3. That, it being understood that there exists in Canada a Board appointed by the Government which deals with the manner in which contracts are carried out by State-aided railways in their relation to the commercial public, this meeting is of the opinion that it is desirable that a similar system should be adopted in connexion with any subsidized line of steamships and telegraphs, and makes the suggestion that the existing Board may be able to assume this duty.

4. That, in the opinion of this meeting, it is desirable that a Trade Commissioner for the whole of the British West Indies should be appointed, whose duty should be to foster the sale of West Indian products in Canada.

5. That, in the opinion of this meeting, it is desirable, in view of the present unsatisfactory steamship service between Canada and the British West Indies, that an improved regular service of fast steamers having adequate passenger accommodation should be installed.

6. That, in the opinion of this meeting, the views expressed by the representatives of Barbados, Antigua and St. Kitts are in substantial agreement, and present a uniform story for the Royal Commission.

After the resolutions were passed, the visitors were entertained at luncheon by the Antigua members of the Conference, at which the Governor presided. After the health of His Majesty the King had been duly honoured, his Excellency proposed the health of the visitors from Barbados and St. Kitts-Nevis, this toast was responded to, on behalf of the visitors, by Dr. F. Watts and the Hon. F. J. Clarke. In the afternoon the visitors were taken to Friar's Hill, the property of the Hon. J. J. Camacho, to see the Santa Cruz system of sugar manufacture installed there, and to view the surrounding country. While at Friar's Hill they were hospitably entertained by Mr. Harper, the manager of the estate.

On Thursday morning, January 13, the members were taken by rail to North Sound estate and shown the various ploughs, cultivators, etc., used in what is known as the Louisiana system of cultivation, at work. These implements, which

were mainly drawn by 16-hand Kentucky mules costing some £65 each, are used after the land is broken up by means either of a steam plough, or by an ordinary plough drawn by oxen. After the land is thoroughly turned up, it is harrowed and then ridged, the ridges being smoothed and rendered even by means of cultivators, and the trenches cleaned out with a double mould-board plough. In the field in which the cultivation was being carried out, it was proposed to plant the cane cuttings in the bottom of the furrow. The visitors were however informed that, in some instances they are planted on the top of the ridge.

On leaving North Sound, the party was taken to Montpelier estate, where they were met by Mr. A. St.G. Spooner. At this estate, the Santa Cruz system was in full operation, crushing and evaporating the juice from the remains of canes from which cuttings had been taken for replanting the estate. From Montpelier they proceeded to Parham New Work and after inspecting the sugar works, which is also based on the Santa Cruz system, they went to Parham Hill, the residence of the Hon. J. F. Foote, where they were kindly entertained by Mrs. Foote. In the evening, the members of the expedition were entertained at dinner by his Excellency the Governor and Lady Sweet-Escott.

On Friday, January 14, at 10 o'clock, the visitors from Barbados and St. Kitts-Nevis met in conference the representatives of the Antigua Agricultural and Commercial Society, when the following subjects were brought forward and discussed :—

(1) 'Five years' working of the Antigua Sugar Factory', by Mr L. I. Henzell.

(2) 'Muscovado Sugar-Making by Steam Boiling', by Mr. A. St.G. Spooner.

(3) 'Implemental Cultivation', by Messrs. E. Moody Stuart and I. E. Dyett.

(4) 'Systems of Agricultural Education', by Dr. F. Watts.

(5) 'The Introduction of Insectivorous Birds', by Mr. G. Moody Stuart.

FIVE YEARS' WORKING OF THE ANTIGUA SUGAR FACTORY.

BY L. I. HENZELL,

Manager of the Antigua Sugar Factory.

The Gunthorpes sugar factory, which belongs to the Antigua Sugar Factory, Ltd.,* was erected by the Mirrlees Watson Co., Ltd., toward the close of 1904 and the beginning of 1905. When first erected, it consisted of two 30″ × 60″ 3-roller mills, a triple effet, two vacuum pans, one strike mixer, five centrifugals and four filter-presses. That year, 15,860 tons of cane from 1,486 acres, i.e., at the rate of 10·8 tons per acre, was crushed. From these canes 1,634 tons of sugar equal to 1·1 ton of sugar per acre, was made. The canes yielded 10·3 per cent. of sugar and it took 9·7 tons of cane to make a ton of sugar. The average output of the factory per week was 102 tons of sugar; 7·74 per cent. of sucrose was lost in the megass, in spite of the fact that maceration water at the rate of 13·4 per cent. was applied. The sugar with its resulting molasses averaged £12 15*s*. 5*d*. per ton, and the factory made a net profit of £3,928, half of which was paid to the cane-growers as a bonus of 2*s*. 6*d*. per ton. The contracting planters received a total of 11*s*. 1*d*. per ton of cane, i e., a first payment of 11*s*. 6*d*. plus 2*s*. 6*d*. bonus. The cost of producing a ton of sugar that year was as follows:—

	£	s.	d.			
Canes	5	12	4			
Factory charges	2	10	0			
Railway charges		4	6			
Administration		8	0	£8	14	10
Interest and other minor charges		16	4		16	4
				£9	11	2

This total, deducted from £12 15*s*. 5*d*., left £3 4*s*. 3*d*. as the profit per ton of sugar.

In 1906, a new filter-press and a centrifugal were installed. That year, 24,676 tons of canes from 1,925 acres, or 12·8 tons per acre, produced 2,349 tons of sugar, or 1·2 tons per acre. The canes yielded 9·52 per cent. of sugar and it took 10·51 tons of canes to make a ton of sugar; 7·58 per cent. of sucrose was lost in the megass, as owing to the shortness of water, only 9·1 per cent. of maceration water could be used this year. The sugar with its resulting molasses averaged £8 1*s*. 8*d*., and the factory only made a profit, after allowing for the sinking fund, of £331 17*s*. 10*d*., or a bonus of 4*d*. per ton to the contracting

*The following references to the Antigua Sugar Factory, in the publications of the Department, may be useful: *West Indian Bulletin*, Vols. VI, pp. 60 and 377; VIII, p. 11 and 317; IX, p. 79; *Agricultural News*, Vols. IV, p. 12; V, pp. 49 and 259; VI, pp. 131 and 145, VII, pp. 81, 104, and 193; VIII, pp. 51, and 123. [Ed. *W.I.B.*]

planters, who received altogether 7*s*. 5*d*. per ton of canes. The cost of manufacture per ton of sugar this year was as follows :—

	£ s d.	
Canes	3 18 10	
Factory charges	2 8 3	
Railway charges	10 11	
Administration	4 9	£7 2 9
Interest, etc.	12 6	12 6
		£7 15 3

This year the factory's output averaged 117 tons of sugar per week.

In 1907, there were several additions to the factory and railway, of the total value of £3,300, among other things being a 24″ × 60″ Krajewski crusher, which added considerably to the efficiency of the crushing plant. Owing to the more efficient crushing, the sucrose in the megass was reduced to 6·48 per cent., and there was a distinct gain on the output of 8·75 ton of sugar per week. This year, 40,782 tons of canes were crushed from 2,735 acres, or 14·9 tons per acre, from which was made 4,230 tons of sugar, equal to 1·6 tons of sugar per acre. The canes yielded 10·37 per cent. of sugar and it took 9·64 tons of canes to make a ton of sugar. The sugar with its resulting molasses averaged £9 16*s*. per ton, and the factory made a profit of £6,345, half of which was paid to the contracting planters as a bonus of 2*s*. 3*d*. per ton of canes, which together with an original payment of 10*s*. per ton, made the amount the planters received that year 12*s*. 3*d*. The cost of manufacture that year was as follows :—

	£ s. d.	
Canes	4 16 5	
Factory charges...	2 2 1	
Railway charges	9 7	
Administration ...	2 10	£7 10 11
Interest, etc. ...	6 10	6 10
		£7 17 9

In 1908, more additions were made to the factory, including three new centrifugals, making a total of nine. This year, 43,060 tons of canes from 3,205 acres, or 13·4 tons per acre were crushed, which produced 4,695 tons of sugar, or 1·46 tons per acre. The canes yielded 10·90 per cent. of sugar, and it took 9·17 tons of canes to make a ton of sugar. The sucrose lost in the megass was further reduced to 6·05 per cent., 20·9 per cent. of maceration water being used. The average price obtained per ton of sugar was £11 15*s*. 9*d*., and the factory made a profit of £14,163. The planters received a bonus of 5*s*. 2*d*. per ton of canes, in addition to a first payment of 10*s*. 9*d*., = 15*s*. 11*d*. The cost of manufacture this year was as follows :—

	£	s.	d.	£	s.	d.
Canes	5	5	3			
Factory charges	2	3	5			
Railway charges		11	7			
Administration		3	2	£8	3	5
Interest, etc. ...		7	7		7	7
				£8	11	0

In 1909, further additions were made to the factory. This year, 37,284 tons of cane were crushed from 3,342 acres, or 11·15 tons per acre. This made 3,995 tons of sugar, or 1·2 tons of sugar per acre. The canes yielded 10·72 per cent. of sugar and it took 9·33 tons of canes to make a ton of sugar; 6·02 per cent. of sucrose was lost in the megass, 19·4 per cent. of maceration water being used. The sugar with its resulting molasses averaged £10 7*s*. 5*d*. per ton, and the factory made a profit of £8,267. The contracting planters received a first payment of 10*s*. and a bonus of 4*s*. or 14*s*. per ton of cane. The cost of manufacture was :—

	£	s.	d.	£	s.	d.
Canes	4	19	4			
Factory charges	2	11	9			
Railway charges		9	0½			
Administration		3	3¼			
				£8	3	4¾
Interest, etc.		9	2		9	2
				£8	12	7

The following is a summary of the results of the work of the factory for the five years 1905-9 :—

GUNTHORPES CENTRAL SUGAR FACTORY.

SUMMARY OF RESULTS OF FIVE YEARS, 1905-9 INCLUSIVE.

Year.	Total tons of canes manufactured.	Tons of canes per acre.	Total tons of sugar manufactured.	Tons of canes to 1 ton of sugar.	Gross receipts for sugar and molasses.	Receipts per ton of sugar.	Receipts per ton of canes.	Price paid cane farmer.
					$	£ s. d.	s. d.	s. d. s. d. s. d.
1905	15,860	10·8	1,634	9·70	100,164·20	12 15 5	26 4	11 7+2 6=14 1
1906	24,676	12·8	2,349	10·51	92,832·48	8 4 8	15 8	7 1+ 4= 7 5
1907	40,782	14·9	4,230	9·64	198,979·20	9 16 0	20 4	10 0+2 3=12 3
1908	43,060	13·4	4,695	9·17	265,643·10	11 15 9	25 8	10 9+5 2=15 11
1909	37,284	11·15	3,995	9·33	198,871·10	10 7 5	22 3	10 0+4 0=14 0
Mean for 5 years	32,332	12·61	3,381	9·56	171,315·27	10 11 1½	22 1	9 11+3 2=13 1

Year.	Cost per ton of sugar for— Canes exclusive of bonus.	1. Factory charges.	2. Railway charges.	3. Adminis-tration.	4. Interest, etc.	Cost per ton of canes for 1, 2, 3, 4.	Net value of 1 ton of canes.
	£ s. d.	£ s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1905	5 12 4	2 10 0	4 6	8 0	16 4	8 1½	18 2½
1906	3 18 10	2 8 3	10 11	4 9	12 6	7 3	8 5
1907	4 16 5	2 2 1	9 7	2 10	6 10	6 8	13 8
1908	5 5 3	2 3 5	11 7	3 2	7 7	7 2	18 6
1909	4 19 4	2 11 9	9 0½	3 3¼	9 2	7 10	14 5
Mean for 5 years	4 19 11	2 6 4	9 8½	3 9½	9 3½	7 7	14 4½

With regard to the railway, the year the factory was erected, 5½ miles of line and 140 trucks were installed for carrying the canes. In 1906 it was lengthened ¾-mile, in 1907 2¼ miles, making a total of 8½ miles, and eighty new trucks were obtained. In 1908 it was extended to the town, an additional 3½ miles, giving a total of 12 miles ; and twenty-five new trucks and an extra locomotive were added, making altogether three locomotives and 245 trucks. This year, the sugar was taken to the shipping port on the railway. The railway ran, during 1909, 22,577 miles, a distance nearly equal to the circumference of the earth. The following statement shows the cost of running the railway from September 1, 1908, to August 31, 1909 :—

Cost per ton of cane carried from September 1908 to August 31, 1909.

Railway Running Expenses.

	£	s.	d.	
Wages	202	2	1	
Lubrication	103	2	0	
Fuel, 254½ tons ...	476	0	0	
Other stores ...	7	13	8	£788 17 9

Total tonnage carried.

	Tons.	cwt.	qrs.
Canes	37,285	11	1
Sugar	3,978	0	0
Molasses	196	17	0
Estates' stores	220	13	3
Factory stores	1,027	9	1
Total	42,708	11	1

Running expenses on 42,708½ tons = £788 17*s.* 9*d.* = 4·43*d.* ℔ ton.
Railway maintenance, as per
detailed list, on 42,708½ tons = 1,027 2*s.* 2*d.* = 5 77*d.* ℔ ton.

Total expenses on 42,708½ tons = 1,815 19*s.* 11*d.* = 10·20*d.* ℔ ton.
Received for transport of sugar
molasses, estates' stores = 440 14*s.* 7*d.* = 2·47*d.* ℔ ton.

Actual cost on 42,708½ tons = 1,375 5 4 = 7·728*d.* ℔ ton.
Total cost on 22,577·58 miles = 1,375 5 4 = 14·61*d.* ℔ mile.
do. 213,703·59 ton miles = 1,375 5 4 = 1·54*d.* per ton mile.

Railway maintenance from September 1908 to August 31, 1909.

Repairs to Line.

	£	s.	d.	
Wages	368	9	7½	
Mora sleepers, 551 ...	55	17	4	
Local sleepers, 5,287 ...	264	7	0	
Stones, 994 barrels ...	12	8	6	
Grit, 10 barrels		1	8	
Timber, 1,232 feet. ...	10	15	10	
Stores	4	0	2	£716 0 1½

Repairs to Trucks.

	£	s.	d.			
Wages	26	4	2½			
Timber, 3,010 feet ...	27	7	0			
Stores	16	5	5	£69	16	7½

Overhauling Locomotives.

	£	s.	d.			
Wages	36	11	10			
Shop work	10	9	1			
Stores	20	3	3	£67	4	2

Grading.

	£	s.	d.			
Digging, etc., 4,906·33 cub. yds.	107	16	9½			
Trenching 10,654 rods	45	5	11½			
Weeding	13	19	9½	£167	2	6½

Culverts.

	£	s.	d.			
Wages	1	8	2½			
Cement	5	10	6	£6	18	8½
	Total			£1,027	2	2

The factory was originally erected to take off 3,000 tons of sugar per annum, and cost £45,539. Since then additions have been made to the plant and railway of the value of £14,012, making a total expenditure of £59,371, and the factory is now capable of turning out 6,000 tons of sugar per annum.

Enquiry has been made as to what difference there would be, in the sugar obtained, if the canes contained less fibre than those dealt with at the Antigua Central Factory. Below are reproduced figures given by the Chemist, Mr. J. Lely, who has assumed the sucrose content of the juice to be the same in all cases, and has taken the fibre content of the canes reaching the factory as a standard, viz., 15 per cent.*, and the normal juice lost on 100 fibre as 70 :—

* These figures are approximate, as they depend on the assumption that the sucrose content of the juice in a cane is independent of its fibre content. They are, however, valuable for purposes of comparison. [Ed. *W.I.B.*]

Fibre, per cent.	Normal juice lost on fibre in cane.	Juice in cane = 100 minus fibre, minus 5.	Extraction.	Reduced extraction per cent. on canes.
10	7·0	85	78·0	...
11	7·7	84	76·3	1·7
12	8·4	83	74·6	3·4
13	9·1	82	72·9	5·1
14	9·8	81	71·2	6·8
15	10·5	80	69·5	8 5
16	11·2	79	67·8	10·2
17	11·9	78	66·1	11·9

If 5,000 tons of sugar are made with cane containing 15 per cent. of fibre, and the extraction is 69·5 per cent., then

						tons.
Cane containing	10	per cent.	fibre gives	78·0 ÷ 69·5	× 5,000	= 5,611
,, ,,	11	,,	,, ,,	76·3 ÷ 69·5	,,	= 5,489
,, ,,	12	,,	,, ,,	74·6 ÷ 69·5	,,	= 5,367
,, ,,	13	,,	,, ,,	72 9 ÷ 69·5	,,	= 5,245
,, ,,	14	,,	,, ,,	71·2 ÷ 69·5	,,	= 5,122
,, ,,	15	,,	,, ,,	69·5 ÷ 69·5	,,	= 5,000
,, ,,	16	,,	,, ,,	67·8 ÷ 69·5	,,	= 4,878
,, ,,	17	,,	,, ,,	66·1 ÷ 69·5	,,	= 4,755

DISCUSSION.

[During the reading of the paper, it was explained by the Chairman that the reason for the larger expenditure on the railway, per ton of sugar, in 1908, was that, owing to the extension of the railway to St. John's, it had had to bear the cost of carting the sugar to that port. It was also stated by Mr. Henzell that the average number of people occupied at the factory, in and out of crop, was 250.]

Mr. A. St. G. Spooner compared the method of working at the Antigua Sugar Factory with that at Bendals, in certain respects, pointing out the difference in the ways of dealing with the massecuite that are in operation at the two factories, and stating that, at Bendals, the second sugars are granulated in tanks.

Mr. G. Moody Stuart, at the request of Dr. Pilgrim, dealt with the way in which the sugar produced by the factory is

sold. He stated that the rule was to sell it as nearly as possible as it is made, a little latitude in time being allowed in regard to the state of the market. No unsold sugar was shipped; it was sold in advance of shipment, and sometimes before it was made. Speculation was avoided, as far as possible.

Mr. HENZELL, in reply to a question by the Hon. F. J. Clarke, gave evidence which enabled him to believe that those who sell canes to the factory, but who will not have any share in it, are satisfied with their position.

Mr. J. J. RODEN, in connexion with this question, and as representing an estate which sold cane under these terms, stated that he considered it advantageous for such an estate to do so, rather than to continue to work up its own raw material.

Mr. J. R. BOVELL was informed by Mr. Roden that the reason why the estate which he represented did not commence to sell its canes to the factory immediately on its being opened, was that the factory was not then in a position to take in that area.

The CHAIRMAN, in closing the discussion, intimated that further opportunities would present themselves to the members for gaining any additional information that they may require.

MUSCOVADO SUGAR-MAKING BY STEAM BOILING.

BY A. ST. G. SPOONER, Antigua.

As the works at Montpelier have been seen already in successful operation, it is not necessary to describe this system* of muscovado sugar manufacture at any length. It was introduced a few years ago, by Messrs. Dew, of Antigua, from the island of St. Croix, where it was in successful operation. The essential points are the use of green megass furnaces, and the boiling of the juice by steam, instead of on the copper wall. As far as possible, this should be done by the use of low pressure steam acting on large heating surfaces, so as to ensure rapid boiling without danger of local heating of sugar solutions to a harmful degree; high pressure steam is only used in the finishing or strike pan, which should also have a large heating surface to ensure the exposure of the syrup for as short a time as possible to the high temperature necessary to convert it into 'sling'. The system has a legitimate place in the West Indian sugar industry, for it is especially useful to those planters who, although they are unable to take part in a central factory scheme on terms advantageous to themselves, are still desirous of improving their position, although they may not be able to go to any very heavy expense in doing this, and are willing to take the risks

*It may be of interest to note that this method of making muscovado sugar was described, and its adoption, under certain circumstances, recommended by Dr. Francis Watts in a paper printed in the *Supplement to the Leeward Islands Gazette* for January 17, 1895.

of standing or falling by the future of muscovado sugar and its molasses. Where this system of making muscovado sugar can be employed, it has many advantages to offer over the old way of muscovado sugar-making. In the first place, the manufacturing cost is considerably decreased by the saving of the hands employed in drying, stacking and carrying megass; the work inside the buildings is much simplified and much less laborious, requiring also less skill and supervision. There is also a saving of a few hands in the boiling-house. The manufacture is cleanly, and every operation well under control and observation.

It is, however, not only in the matter of saving of labour that the advantages of the process are apparent. The steady and abundant steam-supply enables the mill to work up to a considerably increased output over that of the ordinary muscovado process, where the steam-supply is often irregular and unsatisfactory, especially in wet or cloudy weather. Again, as long as there is a supply of cane, the work can be carried on in wet or fine weather, by night as well as day, and so a mill and engine of a certain size can be made to deal with a considerably larger output of canes than would have been possible under the old system.

Again, the abundant steam-supply ensures rapid boiling and, as is well known, the more rapidly the juice is converted into 'sling', the less is the inversion that takes place, and the less is the quantity formed of undesirable lime-glucose bodies, and other substances of a nature that interfere with, or retard, the proper crystallization of sugar from the cooling 'sling'. There should never be any scorching of the liquor, such as takes place from local overheating on the copper wall, and the sugar granulates better and cures better in consequence, when made by this process.

At Montpelier, the megass will more than make the sugar if the mill can be kept steadily supplied with cane; even with a somewhat intermittent supply of cane, very little wood has had to be used as fuel.

The system can be practised in places where the natural water-supply would be too small for the vacuum boiling process, or even for the ordinary process of muscovado sugar-making. Once the works are in full operation, the exhaust steam from the engines should all be used up in heating and boiling the sugar solutions. There will thus be a good supply of condensed water for use in the boilers, and very little 'make up' water will be required. In places where the natural water-supply is of a character harmful to boilers, this would be an advantage, as would also the freedom of the water from large amounts of lime and other scale-forming compounds. The process, therefore, lends itself well to the employment of water-tube boilers even in places where the water is 'bad', and with the economy of such boilers it would be possible to get as good crushing as can be obtained without the use of maceration water. Here the process would fall short of the vacuum evaporation process, where the large economy of evaporation in the triple effect enables the megass to serve as sufficient fuel to deal with the evaporation of maceration

water, besides the water from the juice; the megass could not be made to do this in the St. Croix process under any ordinary conditions.

At Montpelier, dealing with about 6 tons of cane per hour, the following hands are employed. This staff will be reduced for the coming crop, by the four hands required to transfer megass from the mill to the boilers, as it is intended to erect a megass conveyor for this purpose:—

5 Men carrying cane, at 1½*d.* per clarifier.
1 Mill feeder, at 1¾*d.* ,, ,,
2 Hands returning badly crushed megass, at 6*d.* per day.
4 ,, carrying megass to boilers, at 1*d.* per clarifier.
2 Firemen, at 1¾*d.* per clarifier.
1 Hand straining mill juice, at 6*d.* per day.
1 Engine driver, at 1*s.* 6*d.* per day.
1 ,, boy, at 10*d.* per day.
1 Hand washing filter cloths, at 6*d.* per day.
1 Clarifier boy, at 10*d.* per day.
1 Screw press and mont-jus boy, at 1*s.* per day.
1 Eliminator man, at 1½*d.* per clarifier.
1 Boiler man, at 1*s.* 4*d.* a day.
2 Boiling-house cleaners, at 7*d.* per day.

Total, 24 hands.

Curing by centrifugals (driven by oil engine), when this is done:

1 Man digging massecuite, at 1*s.* 4*d.* a day.
2 Hands carrying massecuite, at 8*d.* a day.
2 Curers, 1 at 10*d.*, 1 at 1*s.* per day.
2 Sugar carriers, at 8*d.* per day.

Total, 7 hands.

If the massecuite is drained in bags, instead of being cured in centrifugals, the cost would be 1*d.* per bag or, say, 9*d.* per ton of sugar. This pays for digging massecuite from coolers, heading to curing-house and putting into bags. After being left to drain for about five weeks, the bags are shipped without further manipulation than being sown up.

The following figures may be taken as those of average manufacture, although, of course, better results would often be got, and worse ones perhaps less often, if cane-hauling facilities were more on a level with the capacity of the works, and the crop reaped in the best months.

Basis: juice showing by polariscope 1·80 ℔. per gallon of saccharose on leaving clarifier, but analysed at ordinary temperature:—

15·03 tons cane at 108 gallons per ton = 1,624 gallons.

1,624 gallons juice, at 230 ℔. massecuite per 100 gallons juice = 3,736 ℔. massecuite.

3,736 lb. massecuite at 59·9 per cent. = 1 ton sugar and 110 gallons molasses of specific gravity 1·36. Extraction of sugar on indicated sugar = 76·6 per cent. This assumes that the sugar will test about 92° (centrifugalled) and that the molasses will contain (including fine sugar passing through the centrifugal gauzes) about 55 per cent. of sucrose. If the massecuite was drained in bags, the result would be a good deal better as regards weight of sugar; the molasses would be less in quantity and of lower test, but the test of the sugar would be lower and more uncertain. The massecuite per 100 gallons juice would of course be higher with sweeter juice, and lower with weaker juice; it varies, in practice, from 180 lb. to 245 lb. per 100 gallons of juice, the water content being 14 to 15 per cent.

The gallons of juice per ton of canes may be thought low, but it is all that can be obtained, with seemingly good crushing, from the canes now grown on the estate. These consist of the variety White Transparent, and are, on the average, plants, and first and second ratoons.

Such a plant as that at Montpelier can deal with 6 tons of cane per hour, which gives 650 gallons of juice per hour, as a mean. For a 72-hour week the output at the above figures would be 29 tons of sugar a week: this would be with night and day work, say 50 tons a week.

The labour cost in the buildings, assuming a 72-hour week, would be about 8*s*. per ton of sugar. During the last crop about 17 tons of cane was actually required to make 1 ton of sugar; but as the object was to make molasses, and not sugar, the conditions were somewhat exceptional: the crop, too, was the smallest, and the canes the most inferior that the estate has produced during the eleven years in which the writer had acted as attorney for it.

It will be interesting to compare the Montpelier massecuite of last crop with Java vacuum pan massecuite, on the basis of the same water content, taking the analysis of average Java vacuum pan massecuite, as given by Prinsen Geerligs (*On Cane Sugar and the Process of its Manufacture in Java*, p. 63). The analyses of Montpelier massecuite were made by Mr. H. A Tempany, of the Imperial Department of Agriculture, whose assistance in the matter I have thankfully to acknowledge.

	Montpelier massecuites.		Montpelier massecuites reduced to a water content of 8·6 per cent.	
	Week ending April 24.	Week ending May 1.	Week ending April 24.	Week ending May 1.
Sucrose	77·4	79·1	83·96	84·90
Glucose	3·5	2·8	3·79	3·00
Non-sugar	·6	·7	·65	·76
Ash	2·7	2·5	2·92	2·68
Water	15·8	14·9	8·68	8·66
Ratio: glucose to ash	1·30	1·12	1·30	1·12

Average Java vacuum pan massecuite containing 8·66 per cent. water :—

Sucrose	81·10
Glucose	6·93
Ash	1·12
Water	8·66
Undetermined	2·19
Ratio : glucose to ash ...	6·20

One is at once struck by the fact that, for the same water content, the Montpelier massecuite contains 3 to 4 per cent. more sucrose, only about half the glucose, and nearly two and a half times the amount of ash. This seems to point out that, even under the vacuum pan process it might be doubtfully possible to boil the water content of Montpelier massecuite down as low as the Java 8·66 per cent., without making too solid a mass to leave the vacuum pan.

The gain in employing the vacuum pan process, over that in making muscovado massecuite, might not therefore be fully realized as regards first sugar.

No analysis of Montpelier molasses has been given, because no sample of the molasses (centrifugalled) has been analysed in which the sucrose was not abnormally high, owing to the presence of very fine sugar in suspension—sugar so fine that subsidence would only take place thoroughly by allowing the molasses to stand for several weeks.

It should be stated that the St. Croix system of manufacture lends itself particularly well to the grinding of small quantities of cane, on shares with the grower. The small grower who brings in a lot consisting of a few tons of cane can have it ground by itself, and the juice boiled separately, without difficulty and without very greatly interfering with the economical working of the factory, and the little lot of juice will make just as good sugar as if it had been a large quantity. The principal loss would be that of time, not that of sugar. In an island like Antigua, where education has not yet advanced among our small cane-growers to the stage at which sugar-manufacturing figures could be appreciated, the separate grinding and manufacture of individual lots of cane would be an obvious guarantee of fair dealing.

The process of rapid boiling by steam is one which evidently tends little to the inversion of the sucrose in the juice. As an instance of this, I may quote the work done for the week ending May 1, 1909, when the true average analysis of the juice was as follows, according to Mr. Tempany :—

Sucrose ...	1·96	℔. per gallon.
Glucose ...	·05	,, ,, ,,
Non-sugars ...	·03	,, ,, ,,
Ash ...	·05	,, ,, ,,
	2·09	℔. per gallon solids.

Sp. Gr. of juice, 1·0783.

Percentage of solids, 10·38.

The analysis of the average massecuite from this juice was

Sucrose ...	7·91	per cent.
Glucose ...	2·8	„ „
Non-sugars ...	·7	„ „
Ash ...	2·5	„ „
Water ...	14·9	„ „
Percentage of solids	85·1	„ „

By calculation, we find that 100 gallons of juice gives 245·53 lb. massecuite; that is, the solids in 100 gallons of juice are the same in weight as the solids in 245·53 lb. of massecuite. But we know by one analysis, namely of the juice, that the solids in 100 gallons of juice contain 196 lb. of sucrose, and by another analysis, namely of the massecuite, we find that the solids in 245·53 lb massecuite contain 194·214 lb sucrose, so that only the difference, or 1·78 lb. sucrose, has been lost by inversion per 100 gallons of juice, that is 1·78 lb. on 196 lb., or 0·9 per cent.

Of course, this process only makes muscovado sugar, even if it be the cheapest and best way of making it; so that the fortunes of the man who pins his faith to it will fluctuate with the prices of muscovado sugar and grocery molasses. Whether the making of these rests on a more, or a less, solid foundation of prosperity than the manufacture of crystal sugar and refuse molasses, is a matter of opinion. It is quite true that a better and more even test can be got under this system than by the old process, and in addition, a high grade of grocery muscovado sugar and a light-coloured molasses are obtainable—a valuable matter where the markets are favourable to products of this class. There is the further consideration that the producer is not quite so confined, as under the old process, to the production of articles perhaps in no very particular request. Like any muscovado process, the system is wasteful, however. For one thing, if maceration was employed, the megass would not provide enough fuel to evaporate both juice and maceration water, and so the good milling work of a modern vacuum pan plant could never be obtained, unless additional fuel were used. In the second place, the production of molasses cannot be reduced below a certain point, and that point is one very appreciably higher than in the case of a vacuum pan plant. If molasses sells at a price at which it is immaterial whether sugar or molasses is made, there will be no loss by this; but whenever molasses is proportionately lower in price, for its recoverable sucrose content, than sugar, then one is wasting money by selling sugar in the form of molasses, and that process is the best one which makes the most sugar and the least molasses.

DISCUSSION.

Mr. H. A. Tempany exhibited a table of glucose ratios which showed the much smaller inversion that takes place in the St. Croix system than when muscovado sugar is produced on a copper wall. He also quoted results obtained on three estates in St. Kitts, which illustrated the same fact.

Mr. A. St. G. Spooner, in reply to various questions, stated that, speaking from memory, he obtained about 115 gallons of molasses for each ton of sugar. He further stated that, in regard to the value of peasant canes at the factory, on the basis of the products obtained from them, this was equal to three quarters of the sugar and three quarters of the molasses, reckoned on the average week's work. In fact, under certain conditions, it would be remunerative to return all the sugar and molasses made from the peasants' canes, in order that the mills may be kept employed.

In regard to the question of extraction, Mr. Spooner said that there was no reason why a more powerful mill should not be used at Montpelier, but that if maceration was employed, the whole of the advantage of the system would be lost. Double crushing had been tried at St. Croix, but it had entailed the use of a larger amount of wood.

Mr. E. Dew explained that double crushing was used in one instance, only, in St. Croix, but this was where the method of manufacture was not purely on the muscovado system. In that island, double crushing was never employed where muscovado sugar, alone, was made.

The Chairman, in closing the discussion, called upon Mr. G. Moody Stuart to read a paper on Implemental Cultivation.

IMPLEMENTAL CULTIVATION.

BY G. MOODY STUART.

It is probable that there has been as much need for improvements in cane cultivation in Antigua as there was for those which have been effected in sugar-making; certainly, as much gain is to be obtained from the former as has accrued from the latter. Even in colonies where, for a long time, the greatest intelligence and ample capital have been devoted to improving sugar machinery, very little had been done toward improving cane-growing until the Imperial Department of Agriculture and kindred institutions came to the assistance of planters. If an engineer could show a gain of, say, 2 or 3 per cent., in the recovery of sugar by an expenditure of many thousands of pounds, the money required for the purpose was not grudged. But all this while, a much smaller sum spent on effecting improvements in the growing of sugar-cane might have brought an increase of 20 per cent. and more, in the sugar crop. There seems to have been little appreciation of this important point.

The cause of this may have been the possession by planters, for engineering questions, of the assistance of highly qualified experts from home, and the circumstance of their adding from time to time, to their staff in the colony, young engineers trained in their profession in England—men who had

not everything to learn in the colony, but who could advise and suggest, and not merely carry on the work according to the old routine. All this while, the field work was given to those who had learned nothing of agriculture elsewhere. The system was practically to teach everything about field work on the estate, so that no one had a chance for knowing more than the local man who taught him. It is probable, too, that it thought that there was little to learn, and that any one was capable of doing the work required.

It was generally the case that the men who held the highest appointments were those who had a capacity for dealing with matters connected with engineering, even if they had not had an engineer's training. The part of the work connected with engineering was of course of vital importance, but it was a fatal mistake for an engineer to control the planting, that is the farming; in the same way it was just as bad policy to have a planter--a farmer--managing the engineering work, as has been the case in these smaller colonies. A man cannot be both an engineer and an agriculturist; and trained agriculturists are required as much as trained engineers. They must not be merely men who have gained their knowledge by experience, but those who have been properly trained in their profession. The Imperial Department of Agriculture is giving much assistance in the training of young men as agriculturists, but for them to become properly qualified, they require more assistance than they can obtain locally; this is now being recognized in Antigua. Only recently an estate manager informed the writer that he hoped to send one of his sons - one who had gained an agricultural scholarship at school here--to Canada, for the purpose of going through a course in agriculture. This is a good sign, and it is hoped that the example will be followed in many cases.

The Imperial Department of Agriculture has also given invaluable help to planters by its labours in connexion with new varieties of canes, and by that in relation to the manurial treatment of the sugar-cane. The amount of work done in the matter of tillage has not been as great; this is rather an affair for planters themselves. Tillage is, nevertheless, quite as important as any other branch of cane-growing work, and the best tillage depends on having the best implements with which to till.

Four years ago, the writer paid a visit to Louisiana, in order to study the system of planting in vogue there. He was very much impressed, not only by the saving in labour resulting from the use of modern implements for tillage, but also by the increase in the cane crops that was obtained by their aid. He was informed by one of the ablest planters in that State that, three years before, there had been a drought lasting ninety days after the time for cane sprouting, and that, where the old system of handwork was still in use--the system which was probably brought from Antigua to Louisiana by two Jesuits, about 1760, along with a dozen sugar-canes, and which has been preserved intact in Antigua until four years ago—the crop suffered very badly, being about half the normal quantity. On the contrary, where modern implements were used, but

only worked every three or four weeks, the crops were still poor, but not to such an extent as those raised with the aid of manual labour alone. The same planter stated that, in the drought of which mention is made, he was not satisfied unless his implements went through all his fields every week. The result was that he obtained a normal crop! He kept the surface of his land so finely powdered and so constantly stirred—in fact maintained such a good dust mulch on the surface—that very little evaporation indeed could take place. The conditions there are different from those obtaining in Antigua and Barbados, for in Louisiana, in the bed of the Mississippi, there is always a supply of moisture in the subsoil, so that the loss of water which is transpired through the canes is not as severely felt as it is in these islands. Nevertheless, it is of great importance to prevent evaporation from the surface of the ground, even if moisture has to be lost through transpiration by the crop.

In an experiment conducted in Antigua about three years ago, under the direction of the writer, one half of a field of sugar-canes was cultivated according to the old system, the other half being worked with implements. At the end of a long period of dry weather, the soil in each half was analysed by Dr. Watts, and it was found that there was 1 inch more water, reckoned in its equivalent as rainfall, conserved in a foot of depth (taken from 4 inches to 15 inches deep) in the part cultivated by the new method than in that worked by hand. In addition to this, the canes growing in the new part had naturally made a greater draught on the water in the soil because more of it was available for them. An extra inch of rain stored up at such a time is an important consideration, and would probably do much more good than an inch from precipitation, for much of the latter would run off the land.

The writer has been informed by the visitors from Barbados that some of the estates there gave only a fraction of their normal yield, last year: in some cases, this fraction did not amount to one quarter of what should be expected. In the writer's opinion, if the soil on these had been tilled at the surface by modern implements, the crop would have much more nearly approached the normal quantity; at any rate, the experiment would be worth trying.

It is difficult to give the actual results of the new methods, from experience, as so much depends on many differing circumstances in various parts of any one estate. It is a fact, however, that the crops have been much heavier on the land tilled with implements than on adjoining land of a similar character, and subjected to similar weather circumstances, which had been cultivated by hand.

Certain difficulties are entailed in the use of the implements. The disc implements, which do excellent work in dry weather, cannot be used, especially in heavy soil, when there is even a slight excess of moisture present. Often after rain, on clay soils, a good deal of time must elapse before either the mules or the larger implements can be allowed on the land; hence the old handwork has to be resorted to at such times. The suggestion is made that a remedy for this would be the employ-

ment of the Planet Junior handwheel hoes when the land has dried sufficiently to bear the pressure of the human foot. It is probable that the land would be less adversely affected by these than by the ordinary hand hoes, and they do far better work at less cost. A few years ago, a friend of the writer employed one of these implements in his kitchen garden at home, and found that one man, using a handwheel hoe, did as much work, and of a better class, with it in twenty minutes, as was performed by another man in two hours, using an ordinary hoe. Thus his labour bill was reduced to one-sixth of the former amount, which is a saving of 83 per cent.

A consignment of the Plant Junior implements was sent to Egypt some years ago, and it is stated that, at the present time, the orders for these from that country are never for less than ten thousand machines at a time. The writer sent out a few of them for trial in Manipur. Here it was urged that they were not a success, as the labourers did better work with their own implements and their own methods. A trial, however, has demonstrated the fact that these implements do excellent work, and forty more of them are required at once.

In the matter of using the handwheel hoe in Antigua, the difficulty has been brought forward that in crop time, weeding has to be done by women, who would not be capable of working the implements. Reference to the Planet Junior catalogue, however, will show illustrations of women working it in sugar-beet fields, as in Hungary, and it is a reasonable conclusion that the women labourers in the West Indies are capable of working the implements as well as the women there.

In regard to ploughs, in Antigua, there has been an adherence to old-fashioned, heavy models in iron. The modern ones made of steel, and shaped in such a way as to turn the earth with the least resistance, effect a great saving. In the writer's opinion the greatest benefit has been obtained by the introduction of Ransome's S. A. E. plough. The P. Y. C. plough of this firm also suits West Indian conditions well.

As to steam ploughs, the opinion of the writer is that, on the whole, they are not worth the heavy outlay. They have certainly given assistance in some ways. They have enabled the fields to be broken up immediately after the cutting of the final ratoons, which has been a great advantage. In addition, they have broken up land which would not have been affected by a cattle plough on account of the hardness of the surface, and at times when there have been labour difficulties, they have been of great value. They cost £3,000, however, and it is probable that the ploughing would have been quite as good if one half of that sum had been spent in obtaining additional cattle, which would never be used for anything but ploughing. This would give extra efficiency, and there is the important consideration, also, of the supplementary manure that would have been provided by them.

[The information that was given at the conclusion of this paper by Mr. I. E. Dyett has since been collated and arranged by Mr. H. A. Tempany, B.Sc., and is presented here in the form in which it was received from him.]

During the past few years, considerable interest has been aroused in the efforts which have been in progress in Antigua toward the replacement of existing methods of cultivation by those at present practised in sugar-producing countries in other parts of the world, in which manual labour has to a large extent been replaced by implements.

The pioneers of this movement have been the firm of Henckell du Buisson & Co., on whose estates these new methods are at present practised to a large extent.

In view of the decreasing labour-supply now being experienced, efforts which tend towards the reduction of the amount of manual labour requisite for the successful growth of crops, must be of prime importance, and, thanks to the courtesy of the firm in question, now that the initial difficulties, incident on the introduction of methods of cultivation differing widely from, and to some considerable extent opposed to, local practice, have been overcome, it is possible to place on record some of the results that have been achieved.

In cane-producing countries in other parts of the world and notably those in which American influence predominates, cultivation by means of horse- or mule-drawn implements has assumed a position of considerable prominence. Systems vary according to the different parts of the world in which they are practised, modifications being adopted to suit the special agricultural conditions which they are designed to meet.

The system selected for trial in Antigua by Messrs. Henckell, du Buisson & Co. is that at the present time practised in Louisiana, the principal sugar-producing State of the United States of America.

With a view to carrying out this scheme in the most practical way, Mr. G. Moody Stuart, a member of the firm, visited Louisiana in 1906, and with the co-operation of Dr. W. C. Stubbs, then Director of the Louisiana State Experiment Station, secured the services of Mr. J. C. Walrond, one of the field assistants of the experiment station, a gentleman with considerable experience of the methods of cane cultivation as practised in Louisiana. Subsequently, Mr. I. E. Dyett, one of the managers in the employment of this firm visited Louisiana for the purpose of obtaining practical experience, and at the end of 1906 some 60 acres of land was laid out on Messrs. Henckell, du Buisson & Co's Estates in Antigua for cultivation under the supervision of Mr. Dyett and Mr. Walrond.

Since then, the system has been much extended, and a considerable portion of the total acreage on the estates under the control of the firm is now cultivated according to this method. At present the system in vogue is to all intent and purposes that originally introduced from Louisiana, without serious modification.

In common with all systems of mechanical tillage, it has for its objects: (a) the reduction of the amount of labour necessary for the growth of a crop of canes by the use of labour-saving appliances, and (b) the conservation of moisture in the soil by the maintenance of a dust mulch through the continuous stirring of the topmost layer.

While the methods at present practised are not necessarily ideally suited to the agricultural conditions obtaining in Antigua, and must in course of time be modified to a greater or less degree, to suit local circumstances, yet it is believed that advances in this direction are bound inevitably to come about, in view of the somewhat irregular and decreasing labour supply combined with the dry climatic conditions that obtain there. Accounts of the methods employed, and the implements used, in this system of cultivation have appeared from time to time in the publications of this Department, notably in the *West Indian Bulletin*, Vol. VIII, p. 106.

As has been stated already, the areas cultivated according to this method have been considerably extended, and for the crop reaped in 1909 on three of the estates controlled by Messrs. Henckell, du Buisson & Co., the yields of the cane were recorded from considerable areas which had been cultivated according to the methods described, and it has been possible to effect some comparsion between yields from fields treated in this manner and others cultivated according to the methods which formerly were universally adopted in Antigua.

For the purposes of this article the estates in question will be designated A, B and C, respectively. Thanks to the courtesy of the firm and of the managers of these estates, the weights of cane obtained during the crop of 1908-9 are available for discussion and review, as are also certain facts and figures concerning the cost of the various operations.

It is unfortunate, perhaps, that the first year in which it has been found possible to effect a comparison of this description should be one in which the effects of drought have been severely felt, since on this account some reserve must be made in drawing definite conclusions respecting results. Nevertheless, it is felt that these results are of great interest.

The results obtained on the different estates are discussed in what follows.

Dealing first of all with plant canes, the areas cultivated according to the different methods, together with the yields of cane obtained, are given in the accompanying table. The total area cultivated according to the Louisiana method on the three estates was 159·5 acres. This gave a total yield of cane of 2,630 tons, while the area cultivated according to the current methods of agriculture practised was 181·7 acres, yielding 3,079 tons. In addition, on estate B, 33 acres were planted according to current methods but were cultivated with implements on the bank during the growth of the young sprouts; the return from this area has been given separately.

The estates in question comprise a variety of soil conditions ranging from heavy non-calcareous clays to moderately

light limestone lands; the fields were all manured with pen manure or its equivalent: the varieties of cane grown included White Transparent, B. 147, B. 306, Sealy Seedling, B. 109, and also small plots of other varieties.

When the total areas cultivated are considered, the differences due to variations in soil and varieties grown tend to disappear. The areas cultivated according to the two methods are nearly equal, and an interesting comparsion is possible between them. From 159·5 acres cultivated according to the Louisiana system, an average return of 16·5 tons of cane per acre was obtained, while from 181·7 acres cultivated according to established local practice, a return of 16·6 tons per acre was given. Thus, as a result of this one season's experience, a considerable area of plant canes, embracing a wide range of soils, cultivated according to the Louisiana system has given a yield practically identical with that obtained from an area of similar size, embracing a similar range of conditions and cultivated according to established practice. This result is interesting and important; but as it is the outcome of one season's work, only, and as that season was abnormal in character, these figures cannot be regarded as decisive: they must be supplemented by further data in subsequent years, before definite conclusions can be drawn. In reviewing these results, it must not be forgotten that, in the operation of planting cane by the Louisiana method, far more cane is used as planting material than in the ordinary methods of established practice; the amount * required by the former is about 2 tons per acre, while by the latter only about ½-ton per acre is utilized.

Before leaving the results obtained with plant canes, it is of interest if a word is said concerning the figures in the third column of the table in which the returns are recorded from 33 acres on estate B, planted according to established local practice, but on which implements were used on the cane bank between the rows during the growth of the young canes. This modification is such as to preclude this area being included in the return from the remaining areas planted according to local practice, hence the figures are given separately. The fact that this area is far smaller than areas cultivated according to the other methods described, and also that operations of this description were confined to estate B, renders a comparison with the average results from the other estates unfair. A fairer comparison is obtained with the area cultivated according to the Louisiana system on the same estate, of which 96·5 acres gave 1,274·5 tons of cane, or 13·25 tons per acre. As compared with this, the 33 acres in question yielded cane at the rate of 15·6 tons per acre, showing an advantage in favour of the older method, with the addition of implemental cultivation on the bank. It is not possible in this instance to effect a direct comparison with plant canes

* The reason why a larger amount of cane is used, in planting, in the Louisiana system than for the ordinary method is that, in the former, nearly the whole cane is required for the purpose. It seems, however, that 'cuttings' or 'tops' might be employed in the usual way. [Ed., *W. I. B.*]

planted according to the established methods and not tilled implementally, since on estate B only $2\frac{3}{4}$ acres were treated in this way, and the relative smallness of this area renders a fair comparison impossible. In respect of the ratoon canes, the total area cultivated according to the Louisiana plan is much less than that with plant canes, while that cultivated by the ordinary cultural methods is very greatly in excess of it. In Table II, a similar statement is given in relation to ratoon canes, to that already given in respect of plants.

The total area cultivated by Louisiana methods is 51·5 acres, which has yielded at the rate of 8·2 tons per acre. The total area cultivated according to current methods is 426·5 acres, and this has yielded at the rate of 9·8 tons per acre. It is felt that such a comparison as this throws weight somewhat unduly on the area cultivated according to existing methods, by reason of its being so much larger than that cultivated according to the Louisiana plan. Accordingly, the attempt has been made to pick out the areas in ratoon canes cultivated by the current method, which are situated adjacent to fields cultivated by the Louisiana method, as it is believed that by adopting this course, a better comparison may be secured.

On estate A, four fields of first and second ratoons, having a total area of 31 acres, situated adjacent to those cultivated implementally, were cultivated according to current local practice and gave a total yield of 303 tons of cane. On estate B, two fields of ratoons, of a total area of 11·5 acres, situated adjacent to those cultivated implementally, gave a total yield of 95·5 tons of cane. On estate C, two fields of ratoons adjacent to that cultivated implementally, had a total area of 23 acres, and yielded 163·3 tons.

These results are summarized in the following table: –

TABLE I.

Estate.	Area cultivated according to the Louisiana system, acres.	Yield of cane, tons.	Area of adjacent field cultivated according to current practice, acres.	Yield of cane, tons.
A.	22·5	218·25	31	303·0
B.	19·0	115·25	11·5	95·5
C.	10·0	90·5	23	163·3
Total	51·5	424·0	66·5	561·8
Average yield in tons per acre.		8·2		8·4

When we review these results, treated in the foregoing manner, we arrive at the somewhat striking fact that from ratoons cultivated over an area of 51·5 acres according to the Louisiana system, and from similarly situated areas of ratoons cultivated according to current methods, almost identical yields are recorded.

Before leaving these results, a word may be said regarding the figures given in the third column of Table II, in which are found the yields recorded from 41·25 acres of ratoon canes on estate B, which, planted according to current practice, were cultivated with implements on the banks. These have yielded at the rate of 14·6 tons per acre—a rate far in advance of the other returns recorded. It should be added that these areas were practically confined to one portion of the estate, and that in this the estate conditions were apparently more favourable than elsewhere.

TABLE II.

1st and 2nd Ratoons.

Estate.	Area cultivated according to Louisiana methods.	Yield of cane.	Area cultivated according to current methods.	Yield of cane.	Area cultivated according to current methods, with the addition of the use of implements.	Yield of cane.
	Acres.	Tons.	Acres.	Tons.	Acres.	Tons.
A.	22·5	218·25	152·5	1,614·7	...	...
B.	19·0	115·25	173·0	1,848·3	41·25	570·7
C.	10·0	90·5	101·0	727·2	...	...
Total	51·5	424·00	426·5	4,190·2	41·25	570·7
Average yield in tons per acre.		8·2		9·8		14·6

An area of 53·25 acres of ratoons situated on this portion of the estate and cultivated according to established methods, yielded at the rate of 13·1 tons to the acre; this affords a fairer basis for comparison than the other estates differently situated.

All these fields received sulphate of ammonia, or its equivalent, at the rate of about 2 cwt. to the acre. The

varieties grown included White Transparent, B. 306, B. 109, B. 147, and Sealy Seedling.

Too much weight cannot be attached to these results, in the case of plant canes, and much more so in that of ratoons. They are of very considerable interest, but the relative smallness of the areas available for comparison as compared with that of plant canes, so greatly increases the outside influences likely to be exerted by differences of soil, the variety of cane grown, and especially by root disease and bad season, that it is necessary to suspend definite judgement until further results have been achieved.

As regards the cost of the various operations, the following two statements give figures for the cost of the different operations in planting and cultivating cane according to the two systems. These figures are supplied by two managers on estates controlled by Messrs. Henckell, du Buisson & Co :—

ESTATE A.

Actual Cost of working 6 acres of land in the Old Style.

	£	s.	d.
Clearing land for plough	1	5	0
Lining		6	0
Ploughing twice	1	17	0
Harrowing twice		6	0
Taking out bars	4	10	0
Trenching	5	12	6
Hoe-weeding	7	8	0
Cross-holing	1	13	0
Planting and supplying	1	5	6
Carting manure	2	0	0
Distributing manure	1	3	0
Cost for 6 acres	27	6	0
„ „ 1 acre	4	11	0

ESTATE A.

Cost of working 6 acres of land in New Style
(Implemental Louisiana Methods).

	£	s.	d.
Clearing land, tying trash	1	13	4
Carting trash from field		18	0
Close-ploughing with cattle plough		18	6
Lining		6	8
Reversing banks		18	6
Trenching	1	17	0
Planting peas		4	6
Cutting plants	1	10	0
Trimming plants	1	5	0
Heading in plants		15	0
Covering plants		4	10
Cultivating, harrowing, etc.	3	9	3½
Weeding		5	6
Horse stable litter, carting and heading in ...	2	15	0
Cost for 6 acres	17	0	7½
„ „ 1 acre	2	16	9

ESTATE B.

Actual Cost of working 1 acre of land by the Ordinary Antigua Method, for one year.

	£	s.	d
Clearing land from trash, tying and carting ...		8	6
Close-ploughing		5	0
Lining for ridging and planting		2	0
Cattle plough		2	6
Taking out bars with fork for ridging ..		11	0
Hoe-weeding (farming) for 39 weeks	2	8	9
Trenching		13	0
Cross-holing...		4	9
Planting		3	1½
Supplying, for 4 times		2	8
Distributing manure		2	1
	5	3	4½

ESTATE B.

Cost of working 1 acre of land by Implemental Tillage, for one year.

	£	s.	d.
Clearing land from trash, tying and carting		8	6
Close-ploughing		5	0
Lining			10½
Ridging		3	4
Trenching (main-drains)		7	0
Cultivating before sowing green dressing (and planting canes)		1	6
Opening quarter drains with plough			4½
Sowing seed for green dressing (by hand) ...			5
Reversing rows to cover dressing		1	6
Planting seed cane		12	6
Off-barring and harrowing when sprouts begin to come up		1	0
Cultivating after ploughing		9	0
Hoe-weeding		2	0
Distributing manure		2	6
Keeping open main and quarter drains ...		1	6
	2	17	0

A study of these results shows that the cost of the actual cultural operations is considerably lower in the case of the Louisiana system.

The necessary stock for working 20 acres of land according to the Louisiana system is a pair of mules. Mules capable of performing this work are estimated to cost £40 each, and they should last for at least ten years. When the work was first inaugurated larger mules costing £60 and £66 each were employed, but subsequent experience proved that cheaper animals could be satisfactorily used.

In the foregoing, the attempt has been made to outline some of the main results achieved in these efforts toward the

improvement of cultural methods in these islands. As has been pointed out already, judgement must be suspended as to the suitability of these methods for adoption, until the accumulated results for longer periods of time are available. At present the system is hampered by the necessity for the adjustment of minor points to special local conditions, and in the course of the adjustment of these points the system must inevitably undergo modification. Whether, with some small modification, the Louisiana system will eventually supplant existing cultural methods, it is far too early to say; but that the introduction of the methods, as an attempt to improve an existing condition, is bound to exert a permanent influence on local agricultural practice cannot be doubted. Even if after careful trial, every implement used was found to be unsuited to local conditions, and every modification of existing practice tried proved a failure, nevertheless, the spirit of systematic progress and experiment engendered by these attempts must have a far-reaching effect on agricultural practice. It is in full accord with the spirit in which this work is conceived and carried on, that free access to, and the publication of, the results so far achieved, are permitted to the public through the agency of the Department of Agriculture.

DISCUSSION.

Mr. I. E. DYETT, in reply to a question by Mr. J. R. Bovell, stated that the manure from the cattle, under the old system, would be more valuable than that from the mules employed to draw the implements, but that he was unable to state what difference it that would make in the figures that had been given by him.

The CHAIRMAN drew attention to the fact that the subject of implemental tillage was not such as could be dealt with adequately under one general expression. There were many different phases and methods to suit a large number of different circumstances, and each merited consideration in its special application. It was erroneous to think that the whole question of implemental tillage was covered by the use of the expression 'the Louisiana system'. The system as adopted in Louisiana may, or may not, be successful in Antigua, but that only dealt with one phase of the subject. Implements may be used to aid, or to modify, any of the methods in vogue, so that the question must be regarded in a broad way.

Mr. A. ST. G. SPOONER said he thought that, without implemental tillage, conditions at Bendals would have become very bad. The chief difficulty had been in the matter of labour, and this had led to the changing of the entire system of cultivation. This change had not been made because it was desired to effect it, nor because a larger return per acre was expected as the outcome of the new methods, but through the fact that it was absolutely necessary if the working of the estate was to be continued. At Bendals, the Louisiana system was not applicable; the implements, with their rather light wheels, would not pass over the deep drains that are necessary

there, so that machines with large wheels had to be employed. An immense amount of damage had been done to the lands by the steam plough, but this was absolutely unavoidable. The problem of laying out the lands afresh had arisen, and as they are very heavy, the cultivation had to be largely done in the dry season. In such a case, it was entirely useless to attempt to use cattle ploughs for the purpose; it was quite impossible to break up the land with such ploughs in the dry season. The difficulty had been surmounted by the use of a harrow invented by Mr. Spooner himself. After harrowing, the drains were laid out 20 to 25 feet apart. The members of the Conference had passed through some of the fields at Bendals recently, and it had been suggested by Mr. Clarke, and agreed to by Mr. Bovell, that 25 feet was too great a distance apart for drains on such lands; in consequence, he had decided to put a drain, 1 foot deep, down the middle of the bed. It had been found that one of the most economical ways of treating the land after it had been broken up was to make two cuts in each furrow with a cattle plough; in this way, as much as 11 acres of land could be banked in a day, with three such ploughs. The most useful plough for the purpose had been one made by Ransome, Sims and Jeffries. In order to keep down weeds, a horse hoe or mule hoe was passed over the soil, but this could only be done when it is dry. An important consideration had been the effecting of a great saving of labour under conditions in which this was scarce.

Continuing, in reply to questions, Mr. Spooner stated that the real reason for moulding up ratoons at Bendals was that the cutting of the canes during crop was performed badly. After moulding up, the trash was generally put back on the banks. The usual plan was to fork one bank for first, and alternate ones for second, ratoons.

Mr. F. R. SHEPHERD, in reference to the plan of moulding up in order to encourage the growth of ratoons, asked if it was the opinion of those present that ratoons spring from the old stock, as it had been shown in St. Kitts that the ratoon canes grow up from an underground stem, or rhizome. It seemed that the only disadvantages entailed in cutting the canes well above the ground was the loss of sugar involved and the increased risk of infection by disease. It did not appear to make any difference in regard to the growth of ratoons. Mr. Shepherd also referred to an interesting experiment that had been carried out last year in St. Kitts. The yield of cane from land where the banks had been split and the ratoons moulded up had been compared with that from land where this had not been done, when the difference was found to be scarcely 1 ton of cane to the acre.

Mr. J. R. Bovell, the Hon. F. J. Clarke, Mr. J. J. Roden, Mr. J. D. Harper and Mr. L. S. Cranstoun also took part in the discussion.

The CHAIRMAN, in closing the discussion, made reference to the question asked by Mr. F. R. Shepherd as to whether ratoon stools are produced from the old stock or from an underground system. Dr. Watts referred, in this connexion, to the work of Mr. G. G. Auchinleck, B.Sc., Agricultural Superin-

tendent, Grenada, in the matter of his discovery of the possession of a rhizome by the sugar-cane. It was very creditable for a young man to have made such a discovery in relation to an old industry like cane-farming, and the question for planters was whether the ratoons sprang from the rhizome or from the buds of the part of the cane that was left after cutting. Mr. Shepherd thought that they arose from the underground system of the cane, and if this was the case, the matter had a very practical bearing on its cultivation, and was one which merited the attention of every sugar-planter.

SYSTEMS OF AGRICULTURAL EDUCATION.

ADDRESS BY DR. F. WATTS, C.M.G.,

Imperial Commissioner of Agriculture for the West Indies.

In commencing his address, Dr. Watts pointed out that a great deal of the work of the Imperial Department of Agriculture was concerned with education. Thus it was that it took its share in the very considerable and important efforts of an educational character that were being made in the West Indies, affording instruction of a less formal nature than that of the schools. It therefore appeared desirable to recognize the educational bearing of this work, and to take steps to ensure that it should be organized into a well co-ordinated system, in order to make certain that its influence should reach and stimulate all classes.

There was a well-sustained effort to afford education having an agricultural bearing in most of the elementary schools throughout the West Indies. This effort had been aided and fostered by the Imperial Department of Agriculture, and called for little attention on the present occasion. Good work was, he believed, being done, and the important principle was now fully recognized that it is necessary, for the education of children in the elementary schools in an agricultural community, that considerable attention should be called to agricultural objects, and that a large part of the time spent in training should be employed in making the children familiar with the fundamental facts concerning such things as the growth of plants, the habits and nature of domestic animals, and with other circumstances connected with the daily life of their surroundings.

It was not necessary, in elementary schools, to attempt much in the direction of technical agricultural training, but considerable interest may be given to the teaching, by illustrating it with object lessons drawn from plants grown in

pots or boxes; by this means, many instructive experiments may be carried out. Later on, useful work may be done by means of school gardens which, in competent hands, constitute a valuable aid to education.

There was no necessity in an elementary school, to have the idea of technical training so brought forward that the pupil has before his mind the production of crops for profit. The fundamental reasons as to how and why things happen will more than suffice for training at this stage, and will encourage a habit of mind directed toward agricultural matters, which will exercise a powerful and useful influence at a later stage. In the school garden, as the pupils grow older, it might be well to attempt the cultivation of definite crops on a small scale, by way of inculcating general agricultural principles.

Reference might be made here to the special facilities for technical training that are afforded to youths from the elementary schools in the Agricultural Schools established in the islands of Dominica, St. Lucia and St. Vincent.

When secondary schools are considered, it was found that agricultural education is permanently established in most of them. Examples where this is the case were afforded in the island of Antigua, in the neighbouring island of St. Kitts, and in Barbados, in all of which good work was being done.

Generally speaking, the teaching in the secondary schools which could be regarded as leading specifically to agricultural matters might be described under the term Elementary Science, and this was a correct description. The inculcation of sound elementary ideas concerning the science upon which agriculture is based would prove invaluable to the pupils in later life. Agricultural matters were introduced in more definite form, as the pupils passed through the schools, and the sciences taught in general terms in the early stages were made later to have specific reference to agriculture, so that, ultimately, the pupils were qualified to pass examinations such as the Cambridge Senior Local Examination in Agricultural Science, the Preliminary Examination in connexion with the Courses of Reading of the Imperial Department of Agriculture, and the Agricultural Examination at Harrison College, Barbados. In the secondary schools, also, much valuable training could be, and was, given in school gardens; but here, as in the elementary schools, care must be taken to keep the idea of technical training subservient to that of general education. Crops might be grown to illustrate general agricultural problems, but the idea of raising them for profit should not be allowed to obscure the educational value of the training.

It was hoped that the time would soon arrive when every secondary school in the West Indies will have its strong, well-developed science side, under the direction of a competent and well-trained science master. Good results were already accruing from this science teaching: young men who have received this training, were coming forward for agricultural work, and these formed the groundwork upon which much of the future success of the West Indies must be built. They

were being utilized in pushing forward the developments which are now evident in sugar production, in cotton-growing, and in the production of such commodities as cacao and limes. Further developments would be determined to a large extent by their energy and skill.

There was, however, another phase of education to which attention might properly be directed to-day. In the forms of it that had just been considered, stress had been laid upon the fact that the period of general education was not the time for technical training; this training should come after the former, and be grafted on to it. In earlier times, a boy was compelled to leave school and then, abruptly, without any previous training, if he desired to enter the planting profession, he had to take up the duties of an overseer on an estate. This created many hardships: the duties expected of the youth were onerous and trying, and there was no one to give specific instruction, or to explain the reasons why things were done, so that the whole position was often irksome and unsatisfactory.

It seemed reasonable to expect that, with the establishment of the Botanic and Experiment Stations, these should serve as the places where technical training may be given. This idea had already been acted upon with a considerable degree of success, so that it may be regarded that the time had fully arrived when the giving of technical training at these stations could be considered to be an integral part of the educational system of these islands.

Arrangements had been made in Antigua and St. Kitts under which the Grammar Schools and the Botanic and Experiment Stations are linked up for purposes of training. Under these arrangements, the privilege had been extended, to a limited number of boys, whereby in the last year or so of their course at the Grammar School, they may spend a large amount of their time at the stations to which reference had been made. This privilege had been regarded as of the nature of a scholarship and had been taken advantage of, in this way. The method of procedure was as follows. A youth was selected who, in the ordinary course of events, would be regarded as having finished, or nearly finished, his schooling. Arrangements were made that he should attend such science, and other, classes at the school as the Headmaster and the Superintendent of Agriculture deem expedient; the rest of the time of the working day was spent at the Botanic and Experiment Stations. Here, the pupil learned facts relating to general routine business; he assisted in the office, having certain duties assigned to him in connexion with the books and records of the station, and with the correspondence; he was instructed in the work of propagating plants and in the care of the garden; he was taught to supervise the labourers employed, to keep records of their work, to prepare the wages sheets and to perform other, similar duties. Further, he took part in the various experiments in progress, and thus learned something of the management of the ordinary crops of the country. As time goes on, he may be provisionally placed in charge of some given section of the work, and thus would find himself in a position of some small responsibility.

All this time, the youth was definitely connected with the Grammar School, in that he attended the required classes and remained subject to school discipline. In order to indicate that the period is one of transition, a small monetary payment was made. This, however, was not to be regarded as wages, but was rather looked upon as affording some little training in the handling and using of small sums of money, and as indicating the severance from the school, and the entrance into responsible life.

The period so employed formed a valuable means of spending what is, perhaps, the most dangerous and troublesome time in the life of a youth. It permitted of the restraints of school being gradually, instead of suddenly, relaxed, thus making a steady and graduated transition from dependent school life to the independent period of wage-earning and responsibility. Most of our educational systems were sadly lacking in provision for this difficult period, which in former times, in many countries and in many branches of industry, was met more or less adequately by a system of apprenticeship. The method now introduced into agricultural training by means of the Botanic and Experiment Stations appeared to be of very considerable utility, and worthy of the careful consideration of parents, schoolmasters and employers.

After a year or so spent in this way, a well educated youth should be quite qualified to take up responsible work as an overseer on an estate. He should have an intelligent idea of the duties required of him, and should prove of value to his employer and worthy of reasonable remuneration.

It might be well to add that the term Cadet is now being systematically employed to designate the youths receiving this training, so that in the reports and other publications of the Department of Agriculture, the use of this term, or of the expression Cadet System, may be taken to have a definite meaning.

When a youth has passed from school into the first stages of practical working life, he found it very difficult to know how he may keep up his studies and connect them with the present and future conditions of his new life. It was in order to meet this difficulty, amongst others, that the Courses of Reading of the Imperial Department of Agriculture had been devised. In following these courses of reading, the student was required to make some exertion, and to exhibit a certain amount of self-control. This was desirable, for such circumstances led to the formation of habits that have a useful bearing on a young man's career. These courses of reading are intended, in the main, to be followed by the young men themselves, but a very considerable amount of assistance had been offered to them voluntarily by the Officers connected with the Department of Agriculture in Antigua, in St. Kitts and Barbados—assistance which he (Dr. Watts), as well as the students, acknowledged most gratefully.

The work of the courses of reading might extend over a long period of a young man's life, and would inculcate habits of study and reading which may, indeed, become life-

long, to his own benefit and to that of the industry in which he is engaged.

What has been accomplished already in connexion with the courses of reading and the examinations associated with them had been very gratifying, and it was hoped that the system may be regarded as being established permanently. The point which it was here desired to emphasize was that there now exists a definite scheme of agricultural education which reaches through the primary and second grade schools into the practical every-day life of all workers in agriculture, and that all these efforts—relating to object-lessons in elementary schools, to science teaching in secondary schools, to school gardens, cadetships, courses of reading, and suchlike—were connected parts of a recognized system, all working harmoniously together with one definite object. This object was the creation of a liking for, and an appreciation of, agricultural pursuits, and the production of trained men to direct the responsible and higher sides of the work.

In all efforts of this kind, it was recognized that progress must be slow: but it was felt already that appreciable commercial results were visible, as the outcome of the system. Men were coming forward who were able to hold their own in agricultural work, and who felt that they may confidently expect to find remunerative employment. Concurrently with this, a demand for trained men on the part of employers was arising, as it was recognized by them that it is better to have such men, rather than those who have not been trained, to whom to entrust their interests.

It was hoped that all intending to follow agricultural pursuits would now come within the influence of the system, and that those intended for responsible positions will pass through the secondary schools, then receive some training at the experiment stations, and continue the lines of study indicated in the Courses of Reading. It was, however, incumbent on the employer to see that a reasonable amount of training goes on in a systematic way when the young men enter upon the first stages of their wage-earning life. Formerly, things were very much left to chance; but now, if good results are to be obtained, employers must recognize, and act up to, their responsibilities.

DISCUSSION.

The VEN. ARCHDEACON BRANCH, Headmaster of the Antigua Grammar School, expressed his gratitude to Dr. Watts for bringing forward, and dealing with, the subject of agricultural education. At the time when he took up the duties of a schoolmaster in Antigua, it was not considered that any great mental capacity was required for agricultural work, and, even now, planters themselves often tried to arrange matters so that their sons should not follow the planting profession. He believed that the contrary opinion and attitude were the correct ones, and that the trend of education in the West Indies should be mainly agricultural, while those with the best mental

attainments, rather than those with the worst, should follow the calling of a planter. In outlining the scheme* initiated by the Imperial Department of Agriculture, that was followed for giving instruction in agricultural science, he emphasized the importance of the fact that every boy in the school received some instruction in science, whether he intended to become a planter or not; that the standard of the science subjects taken was equal to that of the others in the school curriculum; and that the agricultural pupils occupied exactly the same status as the other boys in the school.

The scheme of cadetships was of great value, for it permitted of the exercise of disciplinary influence at a critical period of a boy's career and, in view of its importance, it seemed worthy of extension. The same considerations applied to the system of apprentice overseers, which had effected a great improvement in the conditions of life of those in that position on sugar estates.

Mr. MOODY STUART said that the success of the system of apprentice overseers was due largely to the efforts and sympathy of Archdeacon Branch, and he was able to confirm every statement that had been made by him. Whether it was considered from an internal or an external point of view, the results of it had been good; in benefiting the boys who were leaving school, it had also improved matters on the estates. A few years ago, it was difficult to find men who should receive training and eventually take the place of the existing managers, but it seemed, now, that there was an end of that difficulty.

Mr. L. I. Henzell and Mr. L. S. Cranstoun also took part in the discussion.

The CHAIRMAN, in closing the discussion, stated that, while he was in England last year, Mr. Moody Stuart had approached him on the subject of the introduction of birds into various West Indian islands for the purpose of assisting in the control of insect pests. He now invited discussion on the subject.

After Mr. Moody Stuart had brought forward shortly the main points that merited consideration in the matter, it was resolved that the Antigua Agricultural and Commercial Society be requested to deal with it specially at an early opportunity.

CONCLUSION.

After the above subjects had been considered, the Chairman declared the Conference closed. In the afternoon of the same day, a general meeting of the Agricultural and Commercial Society was held in the Council Chamber under the presidency of his Excellency the Governor, when the subject of the root disease of the sugar-cane was discussed. Mr. H. A. Tempany first read a paper† containing replies to the questions he had addressed to the planters of Antigua relative to the prevalence, or otherwise, of root disease on their estates. This

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*Particulars of this scheme are given in the *Reports* on the *Botanic Station, Experiment Plots and Agricultural Education, Antigua,* for 1902-3 to 1908-9. The fullest account may be found in that for 1906-7. [Ed., *W.I.B.*]

† See page 343.

was followed by some remarks from Mr. J. R. Bovell who exhibited specimens of the principal sugar-cane diseases existing in Antigua, and pointed out the mistake that was made in some instances in ploughing under diseased sugar-cane material and then planting canes directly afterwards. After some discussion, in which the Hon. F. J. Clarke, Mr. S. S. Robinson and others took part, the meeting was brought to a close.

The members of the expedition were to have left Antigua on Saturday, January 15, by the Pickford & Black SS. 'Sobo', but owing to the non-arrival of that vessel until the Monday morning, they were unable to embark for their return journey to Barbados until Monday afternoon at 3 o'clock.

NOTES ON SOME CACAOS AT THE DOMINICA BOTANIC STATION.

BY JOSEPH JONES,

Curator, Botanic Garden and Experiment Station, Dominica.

ALLIGATOR CACAO (*Theobroma pentagona*).

This cacao was brought to Trinidad from Nicaragua, during 1893, by Mr. J. H. Hart, F.L.S., late superintendent of the Royal Botanic Gardens, Trinidad. In February 1900, the Dominica Botanic Station received six plants of this cacao from Trinidad, and in July 1902, one pod, from which plants were raised. These formed the stock with which experiments are being made in Dominica.

The six plants were placed out, and when others had been raised from seed, six more were planted; thus a small plot of twelve seedling plants was formed. As these gave every promise of doing well, a number of shoots were grafted on to Forastero stocks, and an experiment plot of sixty-two grafted plants was started.

CHIEF CHARACTERS.

Theobroma pentagona is very similar in habit of growth to the varieties of *Theobroma Cacao*. The pods are borne in the same way, that is on both trunk and branches. The young leaves of the growing shoots of the true Alligator cacao are pale-green in colour, the rich reddish bronze colouring which is so noticeable in the young leaves of the varieties of *Theobroma Cacao* being absent. The pods are quite different from those of the ordinary cacao, and possess five distinct raised ribs. On

the surface between the ribs are protuberances which have given rise to this species being commonly known by the name of Alligator cacao. The pods are thin-shelled, and when ripe, are soft enough to yield to pressure exerted by the thumb and fingers. If they are dropped on the ground from a height of 5 or 6 feet, they will burst open.

The beans are large and, when cut across, a very high percentage is found to be white in colour. Occasionally, pods may be taken from one Alligator cacao tree, which on examination show that in some pods all the beans are purple in colour; in others, all are white; while in some, both white, pale-purple, and dark-purple beans may be found.

The quality of the beans is apparently first rate. It is thought the proportion of fat in the bean will be found to be much higher than in any other of the varieties of *Theobroma Cacao*.

In preparing the product, it requires only a very short fermentation. During this process, the pulp which surrounds the bean does not drain away readily. On rubbing the beans by hand before the drying process commences, the pulp becomes stringy, and is found more difficult to remove than in the case of ordinary cacao.

This species, under the conditions of climate at the Botanic Station, has so far proved a heavy bearer. A small crop ripens about February, but the bulk of the crop comes in during June, July and August. It is thought that the period required for maturing Alligator cacao pods, that is from fertilization to the time the pod is ripe, is two or three weeks longer than in the case of common cacao. To test this, a record will be kept of the time required to mature both kinds of cacao.

COMMERCIAL VALUE.

In order to obtain expert opinion on the value of the cured beans, samples were forwarded by the Imperial Commissioner of Agriculture, during May, 1909, to the firms of Messrs. J. S. Fry & Sons, Ltd., Messrs. Rowntree & Co., and Messrs. Cadbury Bros. Ltd., with a request that the beans be examined and reported upon. The firms mentioned kindly undertook to do this, and further supplies of cured beans were forwarded for the purpose during August.

Messrs. J. S. Fry & Sons, Ltd., in a letter to the Imperial Commissioner of Agriculture, state: 'We have carefully tried this cacao, and have had chocolate made with it, and are sending you under separate cover a sample for you to test.

'In our opinion, the cacao is not suitable for the English market, as the chocolate made from it has a peculiar taste and is different from that made with the usual cocoas.'

Messrs. Rowntree & Co. reported on the beans as follows: '*Theobroma pentagona* resembles much more closely the finer Criollo varieties of *Theobroma Cacao*; it appears to be identical with a cacao which has been shipped recently from Costa Rica in small quantities. After roasting and grinding, the unfer-

mented bean forms a paste of a good light-brown colour, but of a rather thin and acrid flavour. After subjecting to a mild fermentation, the cacao is greatly improved, and then becomes comparable with Caracas cacao, although it has not quite the refined flavour of the "best Caracas". There should be no difficulty in marketing these beans, but great care would have to be taken with the fermentation. This should be of the character of the fermentation given, for instance, at the Ocumare estates—a fermentation not exceeding three days in duration. By avoiding undue access of air and a consequent rapid rise of temperature, the fermentation will not assume a strongly acid character. The bean of *Theobroma pentagona* prepared in this way should be of value in the preparation of drinking cacaos. I doubt whether its value in any case would ever be as great as that of the finer varieties of Caracas cacao, notwithstanding the splendid appearance and excellent colour of the bean.'

Messrs. Cadbury Bros., to whom 60 lb. of cured beans were forwarded for experiment, write: 'We have made a careful test of the "Alligator" cacao supplied, and find it works out very well. The beans are bold and the colour good. It is not suited for a drinking cacao (lacks strength). We made up a sample of chocolate, from one of our most scientific recipes, of this cacao, only, and send you under separate cover a sample of the result. Though it has a very slight trace of a "strange" flavour, it is, generally speaking, about as good as a great deal of the most expensive cacao of the Criollo type shipped from Venezuela or Ceylon. We have not tested its keeping qualities, which is an important matter.

'You will understand it is a great responsibility to suggest that you should encourage the cultivation of a new cacao on a large scale, but we are quite clear that if the tree is easy to grow, and the product not less than that of the ordinary cacao, it is very well worth while cultivating enough for a further experiment, so that the market value might be tested on lots not less than 20 bags. We would readily give a price equal to that of Grenada for a 100-bag lot, of quality as good as last, and if it came up to our expectations, we should expect to be able to give a higher price.

'The name "Alligator" or "Pentagona" would be a deterrent to the sale, and if it is to be put on the market it should have some name connecting it either with the place of growth in the West Indies, or possibly with an individual.'

CULTURAL EXPERIMENTS.

At the Botanic Station, where Alligator cacao has been cultivated for a number of years, the conditions are generally favourable for cacao cultivation. The situation is well protected from the wind, the soil light in texture, the drainage good. Some of the trees are being grown under light shade and others without shade. The average annual rainfall is 78 inches. From January to June the weather is dry, from July to December there is abundant rainfall, but the conditions are seldom excessively damp. The height above sea-level is 50 feet.

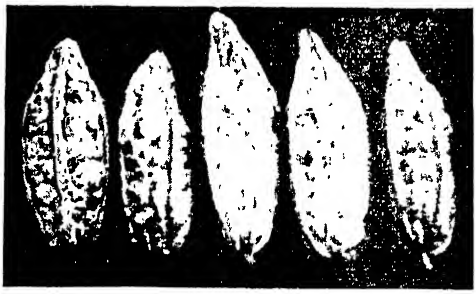
The cultural experiments with Alligator cacao have shown that it is quite unsuitable for the conditions existing in Dominica. Planters are advised not to introduce it on plantations, owing to its delicate character and its tendency to become affected with canker of the stem. Of the twelve seedlings which formed the first experiment plot of this cacao in 1900, only two trees are now alive, the others having been killed by canker. The measures taken to arrest the disease have failed. None of the recommendations put forward by mycologists appear to be able to control canker of the stem in a field of Alligator cacao. At the time of writing, canker had made its appearance in an experiment plot of grafted Alligator cacao and two plants have already been killed, and others are attacked. Early attention, careful excision of the bark, applications of Bordeaux mixture and of tar to the wounds avail nothing. The trees, once attacked, possess no power of recovery, and a plant of this species, in the early stages of canker, is dead, for all practical purposes. In no case where excision of the bark has been made, has the plant been able to commence the formation of new bark, or to make a fight against the progress of the disease. Again, canker is very hard to detect in its early stages. Once the fungus has obtained entrance, it appears to be able to spread considerably through the tissues before it finally breaks through the outer bark. Often, the first indication that a tree is attacked by canker is the yellow appearance of the leaves, but the canker must already be deep-seated, although not noticeable on the bark. to cause an unhealthy appearance of the leaves.

If Alligator cacao were introduced on cacao estates, it would in the course of a few years be attacked by canker, and the disease, once present, can and does occasionally attack the hardy Forastero cacao, and will kill the trees unless remedial measures are taken. In the case of Forastero cacao attacked by canker of the stem, the carrying out of measures recommended in Pamphlet No. 54 of the Department Series. entitled *Fungus Diseases of Cacao and Sanitation of Cacao Orchards*, will control the disease if early action is taken. These trees, after the excision of diseased parts, are able to form new bark and recover from the attack, though it is doubtful if affected trees ever again recover the vigour possessed prior to the attack.

The prevalence of canker in cacao plantations in Dominica is largely due to the variety that is being grown, and is not a question as to whether shade has been provided or not, or of rainfall, although when once the disease is started, shade and dampness would favour its spread. This is very noticeable on the dry leeward coast of Dominica where cacao is grown without shade. Here attempts have been made from time to time to raise the delicate Criollo cacao (which like Alligator cacao is particularly subject to canker, and altogether unsuited for the conditions existing in Dominica), with the result that canker has obtained entrance and caused considerable trouble.

In certain districts on the windward side of the island, where no attempts have been made to grow the Criollo variety, the fields consist of Forastero cacao. Here canker has not been

Theobroma pentagona. (Grafted plant.)



Pods of *Theobroma pentagona.*

Pods of *Theobroma bicolor.*

Theobroma bicolor.

Theobroma angustifolia.

noticed, although the rainfall is considerably heavier than on the leeward coast, and a good deal of the cacao is grown under the shade of breadnut trees (*Brosimum alicastrum*).

Neither the Alligator nor Criollo cacao is sufficiently robust for cultivation under the conditions existing in Dominica, and planters are advised, when opening new areas for cacao, to continue to select the hardy grades of Forastero for planting. It is a matter for regret that the Criollo and Alligator varieties, which produce high grade cacao, cannot be successfully grown on an estate scale in Dominica. Experiments made with Criollo cacao, extending over many years, proved unmistakably that such is the case. The trials at the Botanic Station with *Theobroma pentagona* have shown its delicate character, and consequent unsuitability for cultivation in this island.

In the study of cacao diseases, consideration of the variety or varieties attacked is very important. This point deserves to receive more attention than it has obtained hitherto. In studying the diseases of a cacao plantation there are many factors to be taken into consideration; but in islands situated similarly to Dominica, and of small area, it is evident that the success of cacao cultivation and the freedom of plantations from disease depend very largely on the variety grown.

[Since this article was written, samples of the bark of Alligator cacao trees attacked by canker have been received from Mr. Jones at the Head Office of the Imperial Department of Agriculture. In sending these, Mr. Jones gives information of which the following is the substance. The disease is spreading very rapidly through the grafted Alligator cacao, which, until its outbreak, was in a healthy condition. The trees are growing on a plot that is mulched annually with leaves. They have not been pruned, for, being grafted plants, they are low and bushy and have not required pruning, as yet; all suckers that have appeared have been removed when they were quite small; the plot is always weeded carefully by hand, no hoes being used. These facts, together with the consideration that the impossibility of infection having taken place through the wounds left after the suckers have been removed is shown by the circumstance that the stock is not attacked until the disease spreads downward from the scion, render it difficult to explain how the fungus has gained an entrance.

An interesting point in connexion with the matter, mentioned by Mr. Jones, is that the disease attacks the scion and rapidly rings the stem immediately above the point of union with the stock. In his opinion, this shows that the hardy stock is able to offer some resistance to the spread of the fungus, with the result that the stem of the scion rapidly becomes ringed. The comparative speed with which the damage is done is shown by the fact that, whereas seedling trees may have one side of the stem affected for a long period before the disease spreads around it, the grafted plants become ringed in a few weeks.

The matter is receiving the attention of the Mycologist, with a view to the identification of the fungus and the suggestion of remedial measures for it.—Ed., *W.I.B.*]

Tiger Cacao (*Theobroma bicolor*).

Two plants of this species were received from Trinidad in March 1898, followed by a supply of seeds during October 1899. As in the case of *Theobroma pentagona*, it was introduced into Trinidad from Nicaragua by Mr. Hart during 1893. The *Bulletin of Miscellaneous Information*, Royal Botanic Gardens, Trinidad, No. 19, states that the beans are used in Nicaragua for confectionary purposes, but it is observed that no chocolate is manufactured from them, as far as Mr. Hart could learn.

CHIEF CHARACTERS.

The few plants placed out have grown very well. It is a hardy kind and commences to bear in the third year after planting. The tree throws up a straight stem to the height of from 8 to 10 feet, at which point it branches. It bears small, red flowers with purple anthers. The heart-shaped leaves, large specimens of which measure 16 inches by 11 inches, are green on the upper surface and glaucous on the lower. The pods are borne on the young branches only. The weight of the fruit brings the branches downward, causing the trees to become umbrella-shaped. The pods, which fall from the trees when they are ripe, are hard and woody, and are marked by ten ribs, five of which are prominent, and meet at the apex of the pod. The five intermediate ribs are less prominent, and do not continue to the apex, but gradually merge into a network of raised veins which cover the surface of the pod between the main ribs.

The beans are medium-sized and, when cut across, are found to be white in colour. The pulp which surrounds the seeds possesses an odour somewhat similar to that of ripe durian fruits.

COMMERCIAL VALUE.

As it was desired to obtain expert advice as to the value of the beans, samples were prepared and forwarded to the leading cacao manufacturers in England.

Messrs. J. S. Fry & Sons, Ltd., in reporting on the samples, stated: 'We are sorry to say that we do not like the quality of the sample *Theobroma bicolor*, and do not consider it suitable for the English market, the flavour being poor and undesirable.'

Messrs. Cadbury Bros., Ltd., stated: 'The Tiger cacao from a cacao or chocolate manufacturer's point of view is of practically no value.'

Messrs. Rowntree & Co. reported: 'The bean of the *Theobroma bicolor* has a mild nutty flavour which is not altogether agreeable. After roasting and grinding, it forms a paste which has no pleasant characteristic. It certainly would have no value for manufacturing purposes, as a substitute for ordinary cacao, neither would it be of value as a substitute for almonds or any other nut. I am unable to suggest any commercial outlet for this bean.'

MONKEY CACAO (*Theobroma angustifolia*).

Two plants of the above were received from Trinidad in November 1907. Both have grown very well, and one has already flowered. As soon as fruit is produced, seedlings will be raised for trial as stocks on which to graft good forms of cacao. This species is commonly known in Nicaragua as Monkey Cacao. The seeds are not known to be of commercial value.

THE ROOT DISEASE OF SUGAR-CANE IN ANTIGUA.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S.,

Government Chemist and Superintendent of Agriculture for the Leeward Islands.

In 1905 a circular was sent by Dr. Watts to the majority of estate owners and managers in Antigua, with the object of endeavouring to ascertain what was the position of the sugar industry of the island with regard to cane disease. As a result of this, the opinion was elicited that very little disease was present in the canefields of Antigua. From this opinion Dr. Watts expressed dissent and stated that, as a result of his own observations, he had concluded that root disease of sugar-cane (*Marasmius sacchari*) was present in Antigua to a larger extent than most persons imagined. During the four and a half years that have elapsed since then, the presence of this disease has become more and more generally recognized. At the present time, it is by many admitted to be present in our fields on every hand, and that measures for its suppression are necessary in order to safeguard the industry.

The subject was again discussed at a general meeting of the Antigua Agricultural and Commercial Society, held on Friday, January 14, 1910. In order to assist in the discussion and to endeavour to ascertain to what extent the disease is present, as well as to find out how far it was recognized, a list of questions, with a request for answers at an early opportunity, was sent to the leading owners and managers in the island. These questions, with the answers that were given to them, elicited the information that is given below.

In all, circulars were sent to fifty-three planters and forty-three replies were received.

Question 1.—Have you observed that root disease of sugar-cane is prevalent on the estate under your charge? If so, to what extent?

In ten of these replies the opinion was expressed that the disease was prevalent on the estates under the charge of the planter writing the reply. In twenty-four it was considered that the disease was present to a small extent, only; while in nine cases it was stated that no disease was present on the estate.

Question 2.—Do you consider that it has increased in extent during the past few years?

Dealing with the replies to this question, opinion appears to be divided. On the whole, the tendency seems to be towards the idea that it has done so; on the other hand, the fact that it has of recent years become better recognized is regarded by some as rendering it difficult to say whether it has really increased or not.

Question 3.—Which do you consider most attacked, plants or ratoons?

Opinion appears to be fairly unanimous, to the effect that it is the ratoons which suffer most severely.

Question 4.—Have you noticed that the disease is more prevalent on any one type of soil?

Regarding this question, the consensus of opinion appears to be that the disease is more prevalent on heavy soil. On the other hand, in two cases the opinion is expressed that the disease is often at its worst on the lighter limestone lands, and in one of these cases there is the further statement that this may be associated with the fact that artificial drainage is not considered necessary on many of these, and that drainage would in all probability materially improve the situation. seems that very considerable significance may be attached to this observation.

Question 5.—Have you noticed whether any form of treatment of the soil, or otherwise, has resulted in either an increase or decrease of the disease?

In several cases the good results of thorough cultivation appear to have been observed. Early close ploughing and draining, so as to ensure thorough aeration of the soil, and liberal applications of manure, seem to have been recognized in several instances as having served to lessen the prevalence of the disease.

Question 6.—Have you noticed whether any particular varieties of cane are attacked worse than others? If so, what are they?

Question 7.—Have you noticed whether any particular varieties are attacked less than others? If so, what are they?

The question of the susceptibility of different varieties to the disease has evoked a considerable diversity of opinion. On the whole, among those estates on which the prevalence of the disease is admitted, the susceptibility of the White Transparent cane is agreed on with fair unanimity. Similar fair agreement appears to exist that Sealy Seedling and D. 95 exhibit resistance to the disease, especially when grown on heavy soils.

Concerning B. 147, much difference of opinion exists. By some it is regarded as susceptible to the disease; by others, as resistant. A similar state of affairs holds true with regard to B. 208. In this connexion, the known requirements of this cane in the matter of soil conditions may have something to do with the opinion expressed, since it does not give good returns unless the soils upon which it is grown are in high tilth.

Question 8.—If you have not definitely recognized root disease of sugar-cane, have you observed any appearance of retarded or insufficient development of canes under circumstances which would appear favourable to growth?

The great majority of the answers to this were in the affirmative. As is stated above, twenty-three replies were received in which it was admitted that root disease was present to a small extent on the estates concerned, while nine replies stated that no disease of any kind was present. Of these, in the majority of cases, it is recognized that instances of retarded growth have occurred under apparently favourable conditions It was often alleged that this backward condition is attributable to poverty of soil, poor cultivation, or insufficient manuring.

While it is no doubt true that the factors to which this retarded growth is attributed probably had some influence, yet one would venture to suggest that unrecognized root disease may have served as a factor which considerably accentuated the effects of other operating causes.

Question 9.—Have you noticed any decrease in the prevalence of root disease as a result of rotations of (*a*) cotton, (*b*) green dressings, (*c*) provision crops, (*d*) fallow?

In some cases the benefits accruing from rotations have been observed, especially in the case of cotton. Instances are frequently cited of fields which have shown improvement after this crop. Benefit also appears to have been observed in one instance from the rotation of yams, and also from green dressings. On the other hand, it is stated, in one case, that sweet potatos do not form a good rotation.

Question 10.—Have you noticed any increased spread of the disease as a result of the use of pen manure containing material infected with the disease?

No definite case of increase of the disease as a result of the use of pen manure containing material infected with the disease has been observed, but the possibility and likelihood that the diseased material placed in pens may be responsible subsequently for the conveyance of the disease have received full recognition in many instances.

Question 11.—Do you consider that root disease of sugar-cane at the present time is a serious menace to the sugar industry of the island?

The position of the island as regards its future sugar industry is probably appreciated among those planters by whom the prevalence of the disease on their estates is recognized.

The danger likely to accrue from the disease, if it is neglected, appears to be known. The answers to the questions

tend to show that the methods of control which would give satisfactory results are understood.

Question 12.—Are there any other facts which you have noticed which have a bearing on the question?

The only noteworthy observation recorded under this head is the frequently expressed opinion that the present backward condition of the ratoon crop is attributable more to the poor condition of the soil than to root disease.

As was mentioned above, ten replies stated that root disease was prevalent on estates under the charge of managers to whom circulars were sent; twenty-three gave the opinion that it was present to but a small extent, while nine observed that no disease was present. From the situation of the various estates on which the managers state that the disease is prevalent, it appears clear that it is not confined to any one quarter of the island.

As a result of the enquiry, it appears that the presence of the disease has gained considerably in recognition during the four and a half years which have elapsed since investigations relative to cane diseases in Antigua were last instituted by Dr. Watts. Nevertheless, it is felt that, in the case of the majority of the twenty-three replies in which the opinion is expressed that the disease is present to but a small extent, and of the nine in which no disease is stated to be present, the gravity of the situation is not fully recognized.

The fact that the disease does not always exhibit plainly its characteristic symptoms renders its recognition difficult. As under thoroughly favourable conditions, its influence is felt but little, while with the advent of circumstances somewhat unfavourable to growth, the disease asserts itself and magnifies the damage done, a mental attitude has been produced which tends to attribute the ill effects to any cause rather than to that of root disease.

The fact that the cane lands in Antigua, owing to the stress of conditions during past years, have suffered a depletion of plant food from which they are only now recovering, leads to the tendency to attribute the present unsatisfactory position of the ratoon crop to this, rather than to the disease itself; and, while it is admitted that root disease does exist, it is thought that other causes are responsible for the trouble. In short, the opinion is summed up in the words of one reply to question twelve: 'Good tillage, sufficient drainage, heavy applications of farmyard manure and a rotation crop of a green dressing will go a long way towards starving out what is called in Antigua root disease.' While admitting the efficacy of these methods in combating the disease, one would venture to add that, until its presence is fully recognized, no remedies can exert their full effect.

It is an undoubted fact that the plant cane crop of Antigua at the present time is very fair, while the ratoon crop is poorer than the seasonal conditions experienced would altogether warrant. It is true that the young ratoons received a check owing to drought in September and October, but it is

also true that they did not respond as they should have to the rains of November, and this lack of response may undoubtedly be attributed to root disease. It may be added, as a result of the experience of the writer and of the other officers of this Department, that during this and the past season, not one cane-field has been entered in Antigua in which the disease could not be found to a greater or a less extent.

SUMMARY.

(1) As a result of the enquiry, it appears that the root disease of sugar-cane is prevalent in all districts of Antigua.

(2) Although the recognition of the disease is made by some planters, it will have to be largely extended before it is effected by all.

(3) The remedies for the disease appear to be fairly well known, but until the recognition of it attains a greater efficiency, it is doubtful whether they will be applied as generally as is expedient.

THE ROOT DISEASE OF SUGAR-CANE IN BARBADOS.

In a letter dated December 30, 1909, several questions regarding the occurrence of the root disease of sugar-cane (*Marasmius sacchari*) in Barbados, drawn up by the Mycologist to the Imperial Department of Agriculture, were addressed to Mr. J. R. Bovell, I.S.O., Superintendent of Agriculture, Barbados. These questions, together with the substance of the replies given by Mr. Bovell, are presented in the following article.

Question 1.—Is root disease prevalent in Barbados this year on the following crops: sugar-cane, Indian corn, Guinea corn, imphee and sweet potato? If so, to what extent: largely, moderately, or occasionally?

The first part of this was answered by the statements that the root fungus is very prevalent in Barbados on sugar-cane in Mr. Bovell's opinion, and that it is increasing both in extent and virulence, so that, at the present time, there is hardly a field of sugar-cane in Barbados in which the disease cannot be found. The facts in regard to Indian corn had not received special attention, as yet, and therefore no definite opinion could be given. As far as Guinea corn, imphee and sweet potatos were concerned, Mr. Bovell had seen a disease that he believed to be *Marasmius sacchari* on all these crops.

Question 2.—Is root disease more prevalent this year than last year on any of these crops? If so, on which?

In accordance with the reply to question 1, the answer was given that the extent of the root disease on sugar-cane seems to be increasing, and the apprehension was expressed that unless it is possible to obtain a cane that is immune to the fungus, or unless planters raise other crops that are immune, on their lands so as to eradicate the fungus, the position of the sugar industry in Barbados was likely to become precarious. No definite opinion could yet be given in regard to Indian corn. In the case of Guinea corn, imphee and sweet potatos, there is not much of the disease on these crops, nor does it appear to be on the increase in regard to them.

Question 3.—Is root disease of the sugar-cane more prevalent on land that has previously been planted in any one of the other four above-mentioned crops than on land previously planted in cotton, or allowed to lie fallow?

It is very difficult to say whether the root disease is more prevalent on land that has been previously planted in one of the four above-mentioned crops for the reason that, very often, catch crops of Indian corn, Guinea corn, imphee, and sweet potato are grown during the time the land is being prepared for sugar-cane to be planted in the December following the time of reaping of the canes, so that there is little land that has not recently borne one or more of these crops, with which the comparison might be made. In the case of cotton, this is rarely grown as a catch crop in Barbados, so that here the period during which the land is without sugar-cane is twice as long as that when catch crops are grown. As regards the matter of sugar-cane following fallow, no answer to the question could be given, as very little land in Barbados is allowed to lie in that state, the general practice being to grow catch crops between successive crops of cane.

Question 4.—Is root disease of any or each of the above crops more prevalent on land which has previously been planted in sugar-cane than on land planted in cotton, or allowed to lie fallow?

Root disease is not by any means as prevalent, on the crops mentioned, in lands on which cotton has been grown previously: this is the opinion of most of the planters in the island who have made observations. Nevertheless, sugar-cane has been badly attacked, in some instances, on lands where a crop of cotton had been grown during the previous year. Where this has occurred, it is Mr. Bovell's opinion that the land had been manured with farmyard compost made up with the fallen leaves, etc., of canes which had doubtless been attacked by root disease to a considerable extent. It would appear that, generally speaking, the degree to which root disease exists in a given field that had been allowed to lie fallow has an inverse relation to the time during which it had been permitted to remain in that condition. If this was not long enough for the entire decay of the infected material, including the fungus and its spores, then it is probable that sugar-cane planted subsequently would be attacked by the disease.

On the other hand, if all the refuse material from the previous crop of cane was allowed to decay, so that there was no infected matter left to bear the fungus, and if no fresh infection with sugar-cane débris took place, then, provided that healthy plants, with no infection, were put in, it is likely that the canes grown subsequently would be almost, if not entirely, free from the disease. As far as the effect of the other crops in handing on the disease to sugar-cane is concerned, it is hard to gauge this, for while they are growing, the stools and roots of the previous infected crops of sugar-cane are still occupying the soil, making it possible that those crops may be held responsible for an infection that is really due to the existence of this residual diseased material.

DISINFECTION OF IMPORTED PLANTS.

BY H. A. BALLOU, M.Sc., *

Entomologist on the staff of the Imperial Department of Agriculture.

In an earlier part of this volume of the *West Indian Bulletin* (pp. 197-234), the writer has given an account of the laws existing in the West Indies and other British possessions in Tropical America, showing what progress has been made in recent years in the attempt to prevent the introduction of insect pests and fungoid diseases by regulating the importation of plants, by treatment of imported plants on arrival at a port of entry, and by quarantine and inspection after plants are admitted.

The present paper contains summaries of the laws in force in the West Indies at the present time, arranged for convenience of reference, together with directions for preparing and using insecticides and fungicides, and general accounts of hydrocyanic acid gas, carbon bisulphide, sulphur dioxide, Bordeaux mixture and corrosive sublimate. Bibliographical references are given, at the end of the paper, which include the titles of books, papers, etc., that have a bearing on the subject under discussion. The references to the bibliography are made by means of numerals.

When the earliest of these laws were enacted, there were no well-known means of treating imported plants satisfactorily, and as a consequence, all these, from the Jamaica law, No. 4—1884, until the Proclamation by the Governor of Jamaica on September 7, 1901, were only prohibitory, giving power to prohibit or restrict the importation of any or all plants from any or all countries.

* The part of this paper which relates to the treatment of plants for the control of fungoid diseases has been read critically by Mr. F. W. South, B.A., Mycologist to the Department.

The Jamaica proclamation just mentioned is the first legislation providing for fumigation of imported plants in the West Indies, and since that time the term fumigation has come into very general use. It is proposed however, in future, to use the term disinfection to cover all the processes of treatment which may be given to imported plants for the control of fungoid diseases or insect pests, as being a more general term, and including a much greater range than the term fumigation. In the St. Lucia law No. 12, 1910, disinfection is defined as including fumigation.

Disinfection for the control of *fungoid diseases* includes the use of Bordeaux mixture and corrosive sublimate, and the power to quarantine plants suspected or known to be diseased, while for the control of *insect pests*, disinfection includes fumigation with hydrocyanic acid gas, carbon bisulphide and sulphur dioxide, the use of corrosive sublimate and other insecticides, and power to quarantine, as in the case of fungoid diseases.

In the West Indies, only two colonies—Jamaica and Barbados—have issued instructions to the officers concerned, as to the exact method of treatment which should be applied to imported plants on their arrival at the ports of entry. One of the purposes of this paper is to supply similar information to agricultural and other officers who are responsible for such work in other parts of the West Indies.

It may be well to repeat that in this paper, the term plants is used in the sense of seeds, bulbs, roots, cuttings, grafts, buds, fruits and vegetables, intended for propagation, and not for consumption as food, together with the packages, boxes, wrappers, soil and packing material.

Plants and plant material on which any serious fungus disease is known to be present should not be allowed admission into any colony, since many diseases cannot be reached by any method of treatment. Also, plants coming from a country or locality in which they are subject to any serious fungoid disease should not be admitted to any island or colony where that disease is not known. The witch broom disease of cacao in Surinam affords a good example of an instance in which this attitude should be adopted. None of the islands in which cacao is being grown should import, for propagation, any seed or plant of cacao from Surinam, and they should be especially careful not to allow the admission of any soil or packing material which might be infected with the fungus.

In the case of the more wide-spread fungi which are not so severe in their effects as to make it advisable to prohibit the importation of plants from countries in which they are known to occur, it may often be desirable to take steps to free plants from the spores and superficial growths of fungi, on importation.

Sugar-cane plants, pine-apple suckers, and similar plant material may be treated with Bordeaux mixture, and cotton seed (for plant

The destructive insect pests which should be guarded against include the scale insects generally, and several other pests which deserve individual mention.

The cotton boll weevil should be guarded against most strictly. It is the most serious insect pest known in the United States, and it also occurs in Mexico, Guatemala, Cuba, and probably Porto Rico.

Cotton stainers occur in all the West Indian Islands except Barbados, and are in some instances serious pests.

The leaf-blister mite, though not a true insect, is a serious pest in all the cotton-growing islands except Barbados.

SUMMARIES OF LAWS.

The following summaries may be found useful, as showing at a glance what provisions are made in each colony in regard to the importation of plants likely to introduce pests and diseases, and also in which islands certain regulations are in force.

JAMAICA.

Power to prohibit or restrict.

Requires imported plants to be fumigated with hydrocyanic acid gas.

BRITISH GUIANA.

Power to prohibit or restrict.

Power to prescribe conditions under which plants may be imported.

Proclamation prohibits importation of cacao plants and seeds from Surinam.

Proclamation subjects sugar-cane plants and cuttings from Java, Australia, Fiji, Brazil and the West Indies, to the following conditions:—

They may not be imported in any earth or soil.

They must be inspected by the Government Botanist on arrival.

If found to be infected with pests or disease not commonly known in the colony, they may be ordered to be destroyed. Otherwise they may be treated as the Government Botanist may direct.

They may be required to be planted in a nursery apart from general cultivation, subject to inspection during a period of twelve months.

If pests or disease develop, they may be destroyed or treated as directed by the Government Botanist.

TRINIDAD.

Power to prohibit or restrict in the case of coffee plants or seeds, from certain eastern countries, also sugar-

Proclamation prohibits cacao plants and beans from South America, but permits fresh cacao beans and pods from Venezuela and Columbia, provided they come from a place free from disease, and that they are carefully disinfected before distribution in Trinidad.

BARBADOS.

Prohibits seed-cotton.

Cotton seed may be imported from the United States, Cuba, Porto Rico, Mexico, Guatemala, under special license, and special treatment.

Cotton seed used for oil production to be fumigated with sulphur dioxide.

All plants to be fumigated or disinfected, or both.*

Plants may be ordered to be destroyed, if methods of treatment are not likely to be effective with regard to pests or disease found thereon.

Plants may be required to be cultivated apart, subject to inspection for twelve months.

If pests or disease appear, plants may be ordered to be destroyed.

GRENADA.

Power to prohibit or restrict.

Provides for fumigation or disinfection. or both, of all imported plants.

Treatment such as the agricultural authority may consider adequate for the destruction of any insect or vegetable pest.

Power for the agricultural authority to inspect plants after delivery to the importer.

Order prohibits importation of cacao from South America.

ST. VINCENT.

Ordinance with same powers and requirements as Grenada.

Order prohibits all plants from Ceylon, Natal, South India, Mauritius, Straits Settlements. Cacao plants from South America, and banana plants from Trinidad and Tobago.

ST. LUCIA.

Power to prohibit or restrict.

Provides for disinfection, which includes fumigation such as the agricultural authority may consider adequate.

Provides for the inspection of plants after removal.

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* The Barbados Government Order of May 13, 1909, which appears on page 212 of the present volume of the *West Indian Bulletin*, has been replaced by an Order, dated February 17, 1910, which gives the Agricultural Superintendent discretion as to the fumigation and disinfection of imported

Gives power for the destruction of plants after inspection on arrival.

Gives power to require plants to be grown apart, subject to inspection during a period of twelve months.

Gives power to order such plants to be destroyed, if pest or disease appears.

ANTIGUA, DOMINICA, MONTSERRAT, ST. KITTS-NEVIS.

The Ordinances now in force in these islands are very similar. They provide:—

Power to prohibit or restrict.

For the fumigation of all plants subject to the discretion of the agricultural authority.

For the inspection of plants for a period of twelve months.

For fumigation such as the agricultural authority may consider adequate.

DOMINICA.

Proclamation now in force prohibits importation of plants from Dutch Guiana, which may be a means of introducing disease.

VIRGIN ISLANDS.

Power to prohibit or restrict.

BERMUDA.

Regulates importation of bulbs.

The principal provisions of the legislation now in force in the West Indies, for dealing with imported plants to prevent the introduction of insect pests and plant diseases, are shown in the following table :—

TABLE.

	Jamaica.	British Guiana.	Trinidad.	Barbados.	Grenada.	St. Vincent.	St. Lucia.	Dominica.	Montserat.	Antigua.	St. Kitts-Nevis.	Virgin Islands.	Bermuda.
Power to prohibit or restrict plant imports................ ...	+	+	+	+	+	+	+	+	+	+	+	+	+
Inspection on arrival with power to destroy..............		+	+	+			+						
Treatment on arrival :—													
Such as Agricultural authority may consider adequate		+		+	+	+	+	+	+	+	+		
Fumigation at discretion of Agricultural authority......				+				+	+	+	+		
Fumigation with hydro-cyanic acid gas.	+												
Use of other fumigants, washes, dips, etc...........				+									
Subsequent treatment :—													
Agricultural authority to be kept informed of disposition of plants, with right to inspect............					+	+	+	+	+	+	+		
Requires planting apart with right of inspection for a period...................		+		+			+						
May be disposed of as Agricultural authority directs if *known* pests or disease appear		+		+			+						
Power to destroy if *new* pest or disease appears......				+			+						
Legislation prohibiting or restricting the importation of specified plants :—													
Sugar-cane		+	+										
Coffee			+						+	+	+	+	
Cacao		+	+		+	+							
Cotton....................				+									
Bananas						+							

The following concise directions for using the various insecticides and fungicides recommended in this paper are intended for the guidance of all who may have in charge the work of disinfecting imported plants. The first part shows the treatment to be applied to plant material of several sorts, and the second, the applications of the insecticides and fungicides.

Treatment of Plant Material.

Plants.—Growing plants, in pots or packages, bud-wood, grafts, cuttings, suckers, seedlings, ferns, all packing material.

Treatment.—Hydrocyanic acid gas, normal charge for one hour. In the case of ferns and other tender plants exposure should be for a shorter time, say half an hour.

Plants.—Seeds, in packets, or in bulk; plants growing in soil or with roots packed in soil showing evidences of ants, mealy bugs or scale insects, or other insects on roots; plants showing evidences of borers in stems, or of maggots under bark. Fruit, pods, etc., from which seeds are to be planted.

Treatment.—Carbon bisulphide, 1 ℔. to 1,000 cubic feet, if plants can be exposed to the action of the fumes for from twelve to twenty-four hours. A dose of 1 ℔. to 200 cubic feet may be used for a short period, say one to two hours. For fumigating flower and garden seeds in packets and small parcels, make pin pricks in the paper, and use a teaspoonful per cubic foot for two hours.

Plants.—Rose cuttings, etc., from reliable dealers in temperate climates.

Treatment.—If scales are seen, use hydrocyanic acid gas treatment. If no pests are seen, dip in tepid water to which a small amount of Bordeaux mixture has been added.

Plants.—Cane tops and cuttings, pine-apple suckers, any cuttings liable to bring fungoid disease as an external parasite.

Treatment.—Bordeaux mixture.

Plants.—Cotton seed for planting.

Treatment.—Corrosive sublimate. From boll weevil countries, when entry is permitted, insist on certificate of fumigation before shipment, and on arrival, fumigate with carbon bisulphide, 1 ℔. to 200 cubic feet for four hours.

Plants.—Cotton seed in bulk for oil extraction.

Treatment:—Sulphur dioxide applied by means of a Clayton apparatus, using a strength of 5 per cent. under pressure for twenty-four hours.

Use of Insecticides and Fungicides.

HYDROCYANIC ACID GAS. For fumigating growing plants infested with scale insects on leaf or stem, including mango citrus, sapodilla, species of *Anona*, avocado, scions, grafts,

cuttings, bud-wood, and all straw litter, soil and other packing material used in the packing of any plants in this group.

This treatment is preferable when the pests to be destroyed are on the surface, such as scale insects, mealy bugs, and white fly.

CARBON BISULPHIDE.—For fumigating seeds in bulk or in packets, bulbs, material used in packing plants, and especially for insects in soil such as ants, mealy bugs, borers and also nematode worms, slugs and snails attacking the roots. Carbon bisulphide would be preferably used where a considerable penetration is required, and it has the advantage over hydrocyanic acid that even when used in much stronger doses than those recommended as normal, it is not liable to injure the germinating power of seeds, and the foliage of growing plants.

SULPHUR DIOXIDE.—For fumigating cotton seed in bulk, to be used for oil extraction, by means of a Clayton apparatus. Use 5 per cent. gas, and leave room closed for twenty-four hours.

Sulphur dioxide, produced by burning sulphur, is useful for fumigating rooms or buildings, to kill mosquitos, weevils, bed-bugs and cockroaches, but it is injurious to growing plants and seeds for planting, tarnishes silver and other bright metals, and corrodes iron.

BORDEAUX MIXTURE.—For disinfecting cane plants, pine-apple suckers and similar materials.

Bordeaux mixture is used in connexion with imported plants, as a dip or wash, and it serves two purposes :—

The spores and mycelia of superficial fungi are destroyed by it ; also the coating of Bordeaux mixture on the surfaces of the cut ends prevents the growth of any spores that may come into contact with them.

CORROSIVE SUBLIMATE.—For disinfecting cotton seed for planting.

Corrosive sublimate is useful for treating cotton seed for the purpose of killing the spores of fungi.

This is also useful as a protection against leaf-blister mite, and if the seed is to be stored for a time, it would be protected against the attack of rats and mice, and also from beetles and other insects which often attack stored seed.

FUMIGATION WITH HYDROCYANIC ACID GAS.

Chemicals to be used :	
Potassium cyanide ...	98-99 per cent. pure.
Sulphuric acid ...	93 per cent. pure = 1·83 sp. gr.
Water	
Proportions	Cyanide 1 part by weight ; Acid $1\frac{1}{2}$ parts by bulk. Water $2\frac{1}{4}$ parts by volume.
Normal dose	1 oz. potassium cyanide to each 300 cubic feet. 1 gramme to each 10 cubic feet.
Normal exposure	1 hour

The following measurements are given for convenience in estimating the doses for several sizes and capacities of boxes which might be made to answer for fumigating purposes.

Hogsheads and other casks may be found useful for inverting over plants while fumigating, and as these are often to be found on West Indian estates, they have been included in this list:—

For a room or other container with a capacity of :—

250-300 cubic feet ...	Cyanide	1 oz. (30 gm.)
	Acid	$1\cdot\frac{1}{2}$ oz. (45 „)
	Water	$2\cdot\frac{1}{4}$ oz. (68 „)
100 cubic feet ...	Cyanide	$\frac{1}{3}$-oz. (10 „)
	Acid	$\frac{1}{2}$-oz. (15 „)
	Water	$\frac{3}{4}$-oz. (25 „)
40 cubic feet (sugar hogshead, 250 gal.)	Cyanide	8 gm.
	Acid	12 „
	Water	4 „
16 cubic feet (molasses puncheon, 100 gal.)	Cyanide	1·5 „
	Acid	2·5 „
	Water	4 „
8 cubic feet (cask of about 50 gallons)	Cyanide	·75 „
	Acid	1·5 „
	Water	3 „
10 cubic feet (small fumigating box)	Cyanide	1 „
	Acid	1·5 „
	Water	2·25 „

Imperial gallon = 0·16 cubic feet.

Cubic foot = $6\frac{1}{4}$ Imperial gallons.

Fumigation with Carbon Bisulphide.

In fumigating rooms—buildings which may be left closed over night or longer—a dose at the rate of 1 lb. in 1,000 cubic feet will probably be found strong enough.

The following measurements and capacities, with suitable doses of carbon bisulphide for each, are given for convenience of reference. When doses of the strengths indicated are used, the exposure should be from one to two hours, although longer exposure would probably do no harm :—

300 cubic feet (large fumigatorium) ...	$\frac{1}{2}$-lb.
100 cubic feet	2 oz. to 3 oz.
40 cubic feet (hogshead, 250 gallons) ...	1 oz. to 2 oz.
16 cubic feet (puncheon, 100 gallons)	
8 cubic feet (barrel, 50 gallons ...	$\frac{1}{2}$-oz. to 1 oz.
10 cubic feet (small fumigatorium)	
100 bushels of grain (in bulk)	1 lb.

Small consignments of seeds, in bulk, may be treated in a small box by using a teaspoonful of carbon bisulphide and keeping it tightly covered for two or three hours.

The following pages contain general accounts of, and directions for preparing and using, various substances in the treatment of imported plants.

The insecticides mentioned are all fumigants, as it is believed when dealing with plants which are in a condition to be handled and placed in a fumigatorium, that fumigation is a more efficient means of control than spraying. At the same time it may happen that an officer in charge of the disinfection of imported plants, having only a few to deal with, and these infected with only well-known scale insects, would choose to spray or wash them, instead of fumigating.

In such cases, any of the well-known washes might be used, the directions for making which may be found in several of the publications of this Department, especially in Pamphlets Nos. 7 and 22, *Scale Insects of the Lesser Antilles*, Parts I and II.

HYDROCYANIC ACID GAS.

Hydrocyanic acid gas was first used as an insecticide in California in 1886, in connexion with experiments then being tried in the control of the cottony cushion scale, *Icerya purchasi*, which had been introduced some years previously, and had spread and developed to such an extent as to threaten the existence of the citrus orchards in Southern California.

Mr. D. W. Coquillet, working as an agent of the United States Department of Agriculture, first discovered the usefulness of hydrocyanic acid gas, and about six months later Mr. Morse and Professor Hilgard, of the Agricultural Experiment Station of California University, made an independent discovery of the successful results to be obtained by the use of this material.(8)

At first, a considerable amount of injury was caused to the foliage of the fumigated trees, but by continual experiment it has been possible to so perfect the whole operation that no ill effects result from careful work. The tent, by means of which the gas is confined to the tree which is being fumigated, has been gradually improved, and the details have been perfected, of manipulation of tents, of dosage schedules enabling an accurate estimate to be made of cubic contents enclosed by the tent, of the rate of leakage, and of the method of generating and the kind of generator.(11) (12)

In 1893, the San José scale, *Aspidiotus perniciosus*, which previous to that time had been known only in the Pacific States was found in Virginia, and it spread rapidly during the next few years through the eastern states. Investigations showed that this pest had come to the east from California on nursery stock, and it was by means of infested nursery stock that its further distribution was being accomplished. Previous to this time, the use of hydrocyanic acid gas had been almost entirely confined to orchard fumigation in California, but now attention was turned toward it as a substance likely to be useful in the fumigation of nursery stock before shipment from the nursery. Many of the states passed laws requiring that, before nursery

stock could be brought within their boundaries, it should have been inspected by a duly qualified official, who should issue a certificate to the effect that it was free from insects and plant diseases. This brought about the system of nursery inspection and fumigation, and at the present time every state in the United States, and many nations and colonies in all parts of the world, have laws which place certain restrictions on nursery stock or all plant material intended for propagation, and in some instances also, fruits and vegetables intended for consumption.(9) (14) (15)

These restrictions may, as in the West Indies, provide for the total prohibition, or for the fumigation of imported plants on arrival, or they may require that a certificate accompany such imports, stating that the nursery from which they were shipped was free from certain pests, or from all pests of certain kinds, or that the consignment was thoroughly fumigated before shipment.

Since 1894, hydrocyanic acid gas has been used for the fumigation of greenhouses, and during the years 1898-1900, it was proved to be satisfactory as a means of destroying insects in mills, warehouses and granaries, and of destroying bed bugs and other vermin in street cars and railway coaches. It has also a great value for fumigating dwelling houses for the destruction of all sorts of household insect pests and rats and mice.(8)

Hydrocyanic acid gas is extremely poisonous to all forms of animal life, and the greatest care is necessary in dealing with it. Properly used, however, there is no danger to persons conducting the fumigation.

The gas is produced by the addition of a mixture of sulphuric acid and water to potassium cyanide. It is a colourless gas, with a strong odour of bitter almonds, which is very readily detected by any one familiar with it, even though only very minute quantities of it are present. The potassium cyanide should be the fused cyanide 98 to 99 per cent. pure, such as is prepared for miners' use. There is, or has been, on the market a low grade cyanide about 58 or 60 per cent. pure, but this should never be used for fumigating purposes. The sulphuric acid should be a high grade commercial acid with a specific gravity of not less than 1·83.

In the West Indies, the amount of cyanide used is 1 oz. for each 300 cubic feet capacity of the fumigatorium, and 1 gramme for each 10 cubic feet. No account need be taken of the bulk of the plants which are being fumigated. The amount of acid is 1½ times that of cyanide, and the amount of water 1½ times that of acid.

For ordinary purposes, all plants (seedlings, cuttings, buds, scions) intended for growing should be exposed to the normal charge (1 oz. cyanide to 300 cubic feet) for one hour; for tender plants this may be modified either by reducing the amount of cyanide, or the length of exposure, or both.

The matter of regulating the strength of charges and length of exposure is one requiring the exercise of sound judgement, and the experience in each case should be placed on record.

Plants to be fumigated should not be wet. That is, there should be no drops of water upon stems or leaves, and the packing about the roots should not be unusually wet. This condition may be obtained by not watering plants for some hours previous to putting them in fumigating chambers. All wrappings, packing, etc., in which plants are shipped, should be fumigated. Any tight boxes or tightly wrapped parcels should be opened or loosened to give the gas opportunity to penetrate.

Fruits in crates, barrels, or boxes should be opened up sufficiently to allow free access of the gas to all parts of the package.

When all the material is in place, windows and ventilators are closed tightly, leaving only one opening, through which the operator prepares the charge. The materials should be already made up in suitable doses. The cyanide weighed out (1 oz. for a large chamber) should be wrapped in blotting- or filter-paper and kept in a glass-stoppered bottle. The acid and water are measured in suitable amounts, each in its own bottle. Acid should always be kept in glass-stoppered bottles.

The generator should be of earthernware, glass or wood—never metal—and should have a capacity of two or three times the bulk of the chemicals used. For the large chamber a quart bowl will answer the purpose.

The sulphuric acid is poured in first, then the water, and at the last moment the cyanide, still wrapped in the paper, is dropped into the mixture. A lively effervescence immediately takes place and a cloud of vapour is given off. Great care must be exercised by the operator not to breathe this vapour. One full breath of this pure gas would result in death unless immediate steps were taken to revive the victim. To avoid the possibility of accidents, it is much better that an arrangement be made, by means of a string through the side, to lower the package of cyanide into the mixture of acid and water after the door is closed and nothing is left to be done but plug the hole through which the string passes.

After the expiration of the prescribed time, the door and ventilators should be opened, and some time, at least one quarter of an hour, allowed to elapse before any one enters. Care must be taken not to breathe the air from within the chamber when the doors are opened, and no one should enter for at least one quarter of an hour. This should give time for the fumes to become dissipated, and the air inside well purified.

There will be left in the generator a certain amount of residue, which at first will be liquid and later will become much thicker and may even crystallize. It should be emptied at once; this is the first thing to be done after the chamber has been thoroughly fumigated. A hole should be dug in the ground for the residue and every precaution taken to prevent children or animals getting to it, as it is poisonous.

The fumigating chambers which have been erected in the Lesser Antilles have been recently built after general plans furnished by the Department of Agriculture, and they are of

two sizes, one of about 300 cubic feet and one of 10 cubic feet capacity. The uniformity in size is a great advantage since it is possible to have the charges of cyanide put up in hermetically sealed glass tubes, by the chemist who supplies them. There is no weighing done at the time of fumigating. The Agricultural Authority in each island imports the cyanide put up in this way, and although the first cost is slightly more than when bought in bulk, the increased cost does not amount to as much as would the loss through deterioration in storing in a tropical climate, and the wastage in weighing out the small doses needed.

Potassium cyanide is a very poisonous material, and if it were handled and stored in bulk under the conditions existing in these small islands, there would be some danger of poisoning accidents. The hermetically sealed doses almost entirely obviate this danger.

The amount of the dose or charge given in this paper is that originally decided upon in the early trials at Jamaica in 1901, and in Barbados in 1902, viz., 1 oz. for each 300 cubic feet capacity of the fumigating chamber, and 1 gramme for each 10 feet. This was thoroughly tested in the early experiments and still seems satisfactory. In the same way the original relative amounts of acid and water have been retained. That is to say, in the West Indies the amount of acid is 1½ times that of the cyanide, and of the water 1½ times that of the acid, the cyanide being expressed in avoirdupois ounces and the acid and water in fluid ounces.

In building a fumigatorium, the essential point to be considered is the tightness of the enclosure. There should be no leakage of the gas.

In a fairly large fumigatorium, one or more ventilators should be provided, and arranged so as to open and close from the outside; the room should be well ventilated after each fumigation before any one enters.

Doors and ventilators should be shut on felt casements, and be forced in by means of wedges.

It is necessary also to have some arrangement by means of which the generation of gas may be started without danger to the operator, and without loss of gas. This is accomplished in the larger fumigating chambers used in the West Indies by means of a string suspending the charge of cyanide just over the mixture of acid and water. After the doors and ventilators are shut, the dose of cyanide is lowered and the hole plugged.

In construction, the fumigating chamber should be tight boarded with building paper or tarred paper on the inside, with battens over the seams on the outside. In the tropics, the boarding of the sides should be outside the frame.

The tropical climate is very trying to wooden buildings, and great care will be necessary to keep the fumigating chambers from leaking. Cheaply built structures of this kind will need annual repairs, painting, etc., and pains will be required in order that any breaks in the paper may be repaired each time before the fumigatorium is used.

For temporary use, a cask which is tight enough to hold water will serve excellently for a fumigator. A packing case or other box carefully and thoroughly lined with paper may also be used. Plants in packages for shipment, growing in pots, or tubs can easily be fumigated by these means, the cask or box being inverted over the plant with the open side to the ground. The escape of gas may be prevented by banking all round with soil. Paper will always be found useful for covering cracks and crevices in rooms or buildings to be fumigated, whether carbon bisulphide, sulphur dioxide or hydrocyanic acid gas is to be used.

Carbon Bisulphide.

Carbon bisulphide was first used as an insecticide in 1856-7, in killing weevils and their eggs in grain, and later, in 1859, it was used in the control of phylloxera on the grape vines of southern France. By 1873, over 200,000 acres of vines were receiving annual treatment with carbon bisulphide. Since that time this liquid has come to be very generally used in connexion with certain kinds of pests.

Properties. Carbon bisulphide is a colourless, heavy liquid which is prepared on a large scale by passing the fumes of burning sulphur over red-hot charcoal, and condensing the resulting vapours to liquid form by cooling. This liquid is one-fourth heavier than water; it is very volatile, evaporating freely when exposed to the air. The rapidity of evaporation is proportionate to the extent of the exposed surface, as well as to the temperature and the amount of movement of the atmosphere above, and evaporation in partially closed vessels may be prevented by covering the carbon bisulphide with a layer of water. The water being lighter, floats on the surface of the carbon bisulphide, in the way that kerosene floats on the surface of water.

The vapour of carbon bisulphide is 2·63 times heavier than air. It diffuses quite rapidly through the air, but its tendency is to penetrate downward faster than upward, and this characteristic of the gas has an important bearing on its use in certain conditions.

In the ordinary use of carbon bisulphide as an insecticide there is no fear of injurious effect to the operator, if ordinary care is taken. If considerable quantities of the vapour were to be inhaled for a long time, serious results would follow. A greater danger is that of explosion. Carbon bisulphide vapour is very inflammable, and in an atmosphere impregnated with this, an explosion may easily be brought about by the slightest spark, or even by a rather warm surface, and therefore, the greatest care should be taken that no fire or flame, even of a pipe or cigar or cigarette, is brought into contact with this vapour. The risk attending the use of carbon bisulphide is not greater than that attending the use of gasoline, in many ways.

Mode of application. From the fact that success in the use of carbon bisulphide depends on the ability of the user to confine the vapour, this substance has its greatest utility in connexion with those insects which live in the ground and in

stored grains and other products. As a means of control of those insects which attack stored vegetable products, carbon bisulphide has been found extremely useful in fumigating mills, granaries and warehouses, and it has a further application for the fumigation of foodstuffs, books, clothing, etc., in households. In fumigating mills and similar buildings, 1 lb. of carbon bisulphide to every 1,000 cubic feet of space is the usual calculation. In employing it for the purpose, it is necessary to apply the vapour at the top of the bin or box in which the materials are to be fumigated, and in the case of buildings or rooms, the carbon bisulphide should be exposed as high above the floor as possible. Shallow tins or plates are suitable for exposing the liquid, since the evaporation is very rapid, in proportion to the increased surface, and at least 1 square foot of evaporating surface should be calculated for every 25 square feet of floor space. The building that is being fumigated should be closed, if possible for twenty four hours, and no one should enter it, or bring into the immediate neighbourhood of it any fire or flame of any kind. In fumigating material in boxes, bins, barrels, or other comparatively small containers, carbon bisulphide should be exposed in a shallow dish at the top. The carbon bisulphide should be used at the same rate, namely 1 lb. per 1,000 cubic feet, as already suggested in the fumigation of buildings. An easy method of calculation is to use at the rate of 1 lb. to 100 bushels of grain. This is a considerably stronger dose than 1 lb. to 1,000 cubic feet, but even at that strength the germinating power of seeds is not injured, provided they are not exposed to the action of the insecticide for too long a time.

For the destruction of ants, carbon bisulphide has been successfully used, by pouring into the nest one or 2 oz. of the liquid, in several doses. This can be accomplished by making holes with an iron stake, or a stick, and when the carbon bisulphide has been poured in, securely closing the holes. In the same way, it may be used, at the rate of 1 oz. per square yard, for the control of grubs and mole crickets in soils, and it has also been successfully used in the treatment of root maggots attacking garden plants, and of burrowing animals, such as squirrels, gophers, woodchucks, moles, mice, etc.

On account of its peculiar properties, carbon bisulphide has only a limited application in the control of insect pests on growing plants. It may, however, be used for the destruction of borers in the trunks of trees by injecting small quantities of it into the tunnels of those insects. Care should be taken, however, to distinguish tunnels from which the insects have already escaped, since it would merely be a waste of material to apply carbon bisulphide to such holes. Any clean round hole in a tree infested by borers will probably be found to be the opening through which the adult insect has made its escape. Tunnels in which grubs are still to be found can be distinguished by the quantity of chips and excrement, and sometimes the gummy exudations, which indicate their mouths. The introduction of a small quantity of carbon bisulphide into these tunnels will cause the death of the grub

within, especially if the opening is immediately closed with wet clay, grafting wax or similar material. An ordinary machinist's oiler with a spring bottom will be found very useful for applying carbon bisulphide to borers in trees.

Another application for the control of insect pests is as follows: Small plants attacked by scale insects, plant lice and similar insects can be covered over by tight boxes in which carbon bisulphide may be evaporated. The most convenient mode of application is by means of a small opening at the top of the box or tent used for this purpose, through which the dose of carbon bisulphide is poured on to absorbent cotton or similar material and the hole then stopped with a cork. A teaspoonful of carbon bisulphide for each cubic foot will be found sufficient. These covers should be left over the plants for from three quarters of an hour to an hour, and if the amount of a dose is carefully calculated, the insects will be killed without injury to the plants. Seeds which are being kept for planting may be treated in the same way, using a box, or receptacle of convenient size, and carefully estimating the amount of material to be used. Clothes-moths and other insects which attack stored linens, furs, feathers, etc., may be killed by keeping these goods in a tight box or chest, with an opening in the top similar to the one just described, through which carbon bisulphide may be poured, the hole being then closed by means of a cork. This will be found very efficient in protecting from attack all the articles mentioned, and such a chest or box may even be used for the fumigation of books, papers, foodstuffs and all things that are liable to similar attack.

In using carbon bisulphide in the soil, it should be borne in mind that the direct contact of this material with the roots of plants is sometimes injurious, but when applied in comparatively small doses, at a little distance from the plant, there is generally no ill effect. It has also been shown that it has no ill effect on the germination of seeds which have been fumigated, when the dose has been approximately twice as great as has already been mentioned. Perfectly pure carbon bisulphide does not stain laces, or any fine fabrics if it comes into contact with them, but the ordinary commercial material is not pure, and care should be taken not to spill it, when delicate clothing is being fumigated. Foodstuffs are not injured, and the extreme volatility of the vapour ensures that a short period of thorough ventilation will serve to remove all disagreeable taste and odour.

In *Farmers' Bulletin* No. 145, United States Department of Agriculture, from which the foregoing is largely an extract, it is stated that, as a general rule, crops grown upon soil treated with carbon bisulphide are very good, and a short paragraph is devoted to speculation as to the cause of this favourable condition. Figures are given to show the considerable increase in the products from fields of corn and potatos treated with this substance, and it is mentioned that, in a series of experiments on corn, oats, beets, potatos and clover, much the same results were obtained, but,

strange as it may seem, the marked increase was in the case of the clover. It was found that the vapour was not detrimental to the bacteria causing nodules upon the roots of this legume, but rather seemed to favour their multiplication. Furthermore, it was found upon these same plots that the beneficial influence of the treatment was quite apparent the following year, though less marked than in the first year. These observations are of considerable interest in the light of more recent investigations, which indicate that the effect observed is brought about by the destruction of the enemies of the beneficial bacteria. The editorial in two recent numbers of the *Agricultural News* (Vol. IX, Nos. 202 and 203) has been entitled 'The Balance of Life in the Soil', and has contained explanations of the results obtained by partial sterilization of the soil. Carbon bislupbide is mentioned in this editorial as one of the materials experimented with, and the beneficial effect derived from its use is believed to be the result of partial sterilization produced by its action in the soil. In Antigua, experiments are now being carried out on two plots to determine the effect of carbon bisulphide in the soil, on the growth and yield of sugar-canes, and this substance has been experimented with also in Porto Rico, and in other parts of the world.

The effects of soil sterilizaton have been calculated mostly in connexion with the abundance of soil bacteria, and the relation of the destruction of the beneficial bacteria to that of the injurious forms of protozoan and bacterial life.

Nematode worms are abundant in most, if not all, tropical soils, and are very likely responsible for more injury to plants than has generally been ascribed to them. The use of carbon bisulphide will probably greatly reduce the numbers of these minute animals, and experiments should show how great the injury from them has been.

Sulphur Dioxide.

Sulphur has many uses in connexion with the control of insect pests and diseases, and its value has long been recognized.

It is an ingredient in spray mixtures used for the control of scale insects and thrips; it is used in combination, and by itself in treating fungoid diseases such as mildew; and is especially useful against mites, both on plants and animals. The mites which attack plants in the West Indies include red spider, which attacks various crops, the leaf-blister mite of cotton, and the rust mite of oranges and limes. Mange, itch, and scab, among domestic animals and fowls, are often due to the action of mites, and in such cases sulphur is a good remedy.

The fumes of sulphur which are produced by burning flowers of sulphur or brimstone in an open fire have been used in the fumigation of houses, buildings and ships, for the destruction of mosquitos, and for general disinfection after contagious diseases. Applied in this way also, sulphur is a very satisfactory agent for the destruction of household insects, such as bed-bugs, cockroaches, etc. Sulphur fumes have also been employed for the fumigation of plants in the open, but there is no evidence that any satisfactory results have been obtained.

In the West Indies, cacao attacked by thrips, and cocoa-nuts attacked by scale insects, have been fumigated by sulphur fumes, produced by throwing sulphur on small fires burning on the ground among the trees. There is very little probability of any good results from an operation of this sort. In the first place the burning of small quantities of sulphur would produce a percentage of sulphur fumes in the air among the tree branches far too small to kill thrips or scale insects. If large quantities of sulphur were burned and a high percentage of sulphur dioxide produced, leaves and twigs of the plants would probably be severely injured and the entire tree might be killed.

On account of its injurious action on living plants, sulphur dioxide has only a limited application as a fumigant for the destruction of insect pests in connexion with imported plants. The injurious effect is produced by the sulphuric acid, which results from the union of the sulphur dioxide with air and moisture. The leaves and tender shoots of plants are very liable to be killed, and seeds generally lose their power of germination when fumigated with sulphur dioxide.

Mr. C. L. Marlatt, in a paper on sulphur dioxide as an insecticide, (10) gives an account of extensive and careful experiments with the Clayton apparatus, or with Clayton gas, as sulphur dioxide is sometimes known, when produced in this machine.

Sulphur fumes on board ship were first used for extinguishing fires in cargoes of coal or cotton, and they are now used for the destruction of insects and rodents.

The Clayton apparatus produces sulphur dioxide by burning sulphur in an open grate, and it cools the gas, and forces it into the enclosure to be fumigated. A definite percentage of gas may be produced, and the mechanism which forces the gas into the enclosure gives rise to a pressure which greatly increases its penetration. In this way, the use of sulphur is under control. In addition to the advantages due to the apparatus, the points in favour of this gas are its power of penetration, its extremely toxic effect on insects, and the fact that there is no danger from fire.

On the other hand there are disadvantages. Sulphur fumes are destructive to living plants; they destroy the germinating power of seeds: they exercise a strong bleaching effect on wall-papers, fabrics, etc., and a corrosive effect on metal surfaces. The bleaching and corrosive actions are more vigorous in the presence of moisture, and it is therefore of the greatest advantage to have the gas, and the air in the enclosure to be fumigated, as dry as possible.

A Clayton machine has been purchased by the Government of Barbados, for the fumigation of ships from disease-infected ports, and arrangements have been made for its use in the fumigation of cargoes of cotton seed imported for oil extraction, with a view to guarding against the introduction of the leaf-blister mite, or any insect pests which might possibly be introduced with cotton seed. The machine is mounted on a barge which is able to go alongside sailing vessels and fumigate the

cargoes in the holds, which can then be closed for twenty-four hours.

Cotton seed for oil production is not injured by the loss of its power of germination, especially if it is to be ground immediately. Corn, oats, and similar grain to be used for food or for feeding purposes might be fumigated in the same way. On account of its injurious effects, however, sulphur dioxide is not a suitable fumigant for living plants, or seeds for planting.

Bordeaux Mixture.

Bordeaux mixture derives its name from the fact that the mixture of copper sulphate and milk of lime for fungicide purposes originated in the city of Bordeaux in France. It was first used in the form of a thick paste, on vines near the highways to prevent the theft of the fruit. When sprinkled on the vines in this way the mixture was very conspicuous, and as there was a popular idea that it was extremely poisonous, it was a very effective preventive. It is not known when this practice originated, but it was first brought to the attention of viticulturists in 1885. by M. Millardet, Professor of Botany at Bordeaux.

In 1882, Millardet visited the vine-growing region about Medoc and learned from the grape growers there that such vines as they treated with this paste were entirely free from the downy mildew, which was a serious disease. During the next few years M. Millardet carried out experiments with Bordeaux mixture, and demonstrated the great value of copper sulphate and lime as a means of control of those fungoid parasites of plants which live on the surface, or which gain admission through the epidermis.

In the past twenty-five years, Bordeaux mixture has come to have a very wide and varied use. In France for many years it was principally applied to vines as a protection from the diseases peculiar to grapes, but in other countries it was tried in connexion with the control of all fungoid plant diseases.

Bordeaux mixture is safe to use, since it is not a very active poison in its effect on man, and when properly made it does not injure the foliage of plants. It has special value as a preventive application on plants liable to fungoid attack, and the fact that it may be used as a carrier for the ordinary arsenical insecticides gives it even a greater range of usefulness. For instance, Bordeaux mixture to which Paris green, arsenate of lead, or other poison has been added, may be sprayed on trees or other plants, and this gives a protection from the attacks of both insects and fungi. The adhesive properties of Bordeaux mixture enable the arsenicals to remain on leaves or bark much longer than when they are sprayed without the mixture.

PREPARATION OF BORDEAUX MIXTURE.

It has already been stated that Bordeaux mixture is a preparation of copper sulphate (bluestone) and lime in water. The following proportions may be used :—

Copper sulphate 4 ℔., temper lime 4 ℔., water 50 gallons.

The copper sulphate is dissolved in 25 gallons of water in a barrel or wooden tub. The most convenient method is to put the copper sulphate in a coarse sack and hang it from a stick across the top of the cask in such a way that it is just submerged in the water. The lime is slowly slaked in a wooden tub, and water added to make 25 gallons. The bluestone solution and the lime wash are mixed by being poured at the same time into a third cask capable of holding the entire 50 gallons of the mixture. Emphasis is laid on the method of mixing, which may be accomplished by two men, one pouring the copper sulphate solution and the other the lime wash, by means of buckets. Copper sulphate and Bordeaux mixture should always be kept in wooden containers as far as possible, and not in metal, and the slaking of the lime should also be done in wooden vessels.

Bordeaux mixture should always be tested for any excess of uncombined copper salts, which might be injurious to the plants to be treated. There are two recognized tests—the knife blade, and the ferrocyanide of potash test. When the copper sulphate solution and lime wash have been poured together and thoroughly stirred, the mixture may be tested by means of a clean, polished knife blade placed therein and allowed to remain for a few minutes, or even for several hours. If the polished surface shows any reddish deposits of copper, more lime must be added ; but if it comes out bright, the mixture is safe to use. With the ferrocyanide test, it is only necessary to add a drop to a small amount of the mixture ; if any reddish-brown colour is seen, it requires more lime.

Stock solutions of known strengths might be kept made up, so that to prepare Bordeaux mixture it would be necessary merely to pour together a certain amount of the lime stock and the sulphur stock, and add the correct amount of water. If the stock solutions contained 1 ℔. of lime or of copper sulphate in each gallon, the calculations necessary in preparing a mixture of Bordeaux according to any ordinary formula would be a simple matter. For example, to prepare 25 gallons of Bordeaux, according to the 4-4-50 formula, only 2 gallons of copper sulphate stock, 2 gallons of lime stock and 21 gallons of water would be necessary.

Care would have to be exercised that the strength of the stocks was kept constant, as evaporation of the water would tend to concentrate the stock preparation.

Professor Pickering has published in the *Transactions of the Chemical Society* (18), interesting results of experiments in the making and use of Bordeaux mixture, and an account of this work has been given in the summary of the Eighth Report of the Woburn Experimental Fruit Farm.

The author concludes that excess of lime impairs the efficiency of Bordeaux mixture, and that the old formulas for making it were based on wrong principles. He suggests the use of 6 ℔. 6½ oz. of copper sulphate, dissolved in 2 or 3 gallons of water and 2 or 3 ℔. of fresh lime to make 100 gallons of Bordeaux mixture. The copper sulphate is dissolved, and the lime slaked and stirred up in about 100 gallons of

water. When the lime has settled, 86 gallons of the clear lime water is drawn off and mixed with the copper sulphate solution, and the whole made up to 100 gallons. Soft water should always be used, and the mixture tested by the knife blade test or the ferrocyanide of potassium test, and if the copper has not all been precipitated, more lime water should be added.

Made according to this method, 100 gallons of the mixture requires the use of smaller quantities of copper sulphate and lime, than when made according to the old method, and it is said to be equally efficient and no more liable to injure the foliage of plants

Trials in Hawaii (19) however indicate that for treatment of cane tops and plants, Pickering's Bordeaux mixture is not suitable, and it would seem that further experimental trials were necessary before it could be concluded that the old method of making Bordeaux mixture can be replaced entirely by the new one.

DIRECTIONS FOR USING BORDEAUX MIXTURE.

Cane plants and similar plant material to be treated should be immersed in Bordeaux mixture which should thoroughly wet the surface of the plants, the object being to coat them with a film of the copper solution. A wooden crate, or a basket made of galvanized mesh wire, will be found convenient for holding the canes, during immersion in the trough or tank of the mixture.

It would be possible to agitate the mixture and cause it to flow over and between the plants by lifting the baskets gently two or three times, and this would not injure the buds so much as stirring the cuttings when they are thrown into the trough *en masse*.

CORROSIVE SUBLIMATE.

The employment of corrosive sublimate for the disinfection of cotton seed resulted from the experiments which were undertaken early in 1907 at the Government Laboratory at Antigua, and at the Mycological Laboratory of the Imperial Department of Agriculture at Barbados in the same year.

Corrosive sublimate is extremely poisonous to all forms of animal life as a stomach poison, and it also possesses very strong fungicidal and germicidal properties, but on account of its unfavourable action on the tissues of living plants, its application as an insecticide and fungicide is very limited.

In the West Indies, corrosive sublimate is used for the treatment of cotton seed intended for planting, with a view to killing any fungus spores on the surface of the seed, and as a safeguard against the attacks of leaf-blister mite. Whether the eggs of the leaf-blister mite or a resting form of the mite itself are attached to the seed has not been proved, but it is the experience of many planters that cotton grown from treated seed is not attacked as early as that grown from untreated seed.

When used for this purpose, a solution of 1 part of corrosive sublimate to 1,000 of water is employed. This is produced by dissolving 1 lb. of corrosive sublimate in 100 gallons of water, or 1 oz. in 7½ gallons. The cotton seed is immersed in this solution and stirred or agitated so that all parts of the surface of the seed come into contact with the solution. It is necessary to wet thoroughly every portion of the outer surface of each seed, but the seed should not soak in the solution, on account of the danger of starting germination prematurely.

As soon as the wetting is complete, which will generally take about ten minutes to accomplish, the seed should be removed and dried as rapidly as possible, and this process will leave each seed thoroughly covered with a film of corrosive sublimate, the germicidal properties of which will prevent the growth of adherent fungus spores, while its insecticidal properties will guard against the attacks of insects on the seed itself. The seed when removed from the solution is spread in thin layers, in a current of air in the shade, in order that it may dry as quickly as possible. It should be remembered that a considerable quantity of the corrosive sublimate is absorbed by the seed coat, and that after each batch of seed is treated, the solution is more dilute than before. It is estimated that for each gallon of the solution, which costs about ½*d.*, 12 lb. of seed may be satisfactorily treated.

The solution of corrosive sublimate should always be contained in wood, never in metal. A reaction takes place between the wood of the casks and the solution by means of which a considerable amount of the corrosive sublimate is absorbed by the wood. In order that this may not interfere with the results in the disinfection of cotton seed by weakening the solution, the cask should be filled with a solution of corrosive sublimate and allowed to stand over night, when the solution may be run off and the cask will be ready for use.

Bibliography.

The following list of books and papers includes several that have been consulted in the preparation of this article, and others which refer to fumigation or laws in connexion with the importation or shipping of plants, etc., which may be of interest to readers of the *West Indian Bulletin* :—

1. Report on the gas treatment for scale insects. D. W. Coquillet. U.S. Dept. of Agric., *Annual Report*, 1887, p. 123.

The first account published by Mr. Coquillet, who first used hydrocyanic acid gas for fumigating plants, for the destruction of scale insects. Professor Hilgard and Mr. Morse published an account of their experiments about this time.

2. History of the hydrocyanic gas treatment for scale insects, by D. W. Coquillet. U.S. Dept. of Agric., *Insect Life*, Vol. III, p. 457, 1891.

Another account of early trials with hydrocyanic acid gas.

3. Progress in Economic Entomology, by L. O. Howard. U.S. Dept. of Agric., *Year Book*, 1899, p. 150.

The author mentions the progress made in the use of hydrocyanic acid gas for fumigating.

4. Bordeaux mixture. U.S. Dept. of Agric., *Annual Report*, 1893, p. 263.

Historical account and experiments carried out in the use of Bordeaux mixture.

5. Carbon bisulphide for cabbage root maggot, by M. V. Slingerland. Cornell, *Bulletin* No. 78, 1894.

An account of the use of carbon bisulphide for the control of maggots in the soil.

6. Orchard Fumigation, by C. W. Woodworth. University of California, *Agric. Expt. Station Bulletin* 122, 1899.

7. Carbon bisulphide as an insecticide, by W. E. Hinds. U.S. Dept. Agric., *Farmers' Bulletin* No. 145.

A very full account of carbon bisulphide and its uses.

8. *Fumigation Methods*, by W. G. Johnson, 1902. Orange Judd Company.

This book gives a very good account of fumigation with hydrocyanic acid gas and carbon bisulphide.

9. The laws in force against injurious insects and foul brood in the United States. Compiled by L. O. Howard, Ph. D., and A. F. Burgess. U.S. Dept. Agric., Bur. Entom., *Bulletin* 61, 1906.

This bulletin gives in full the laws in force in all the states and territories of the United States (see also 14).

10. Sulphur Dioxide as an Insecticide, by C. L. Marlatt. U.S. Dept. Agric., Bur. Entom., *Bulletin* 60, 1906, p. 139.

This article gives an account of the Clayton apparatus and the use of sulphur dioxide as a fumigant.

11. Fumigation for the Citrus White Fly, by A. W. Morrill, Ph. D. U.S. Dept. Agric., Bur. Entom., *Bulletin* 76, 1908.

The author recommends doses about twice the strength used in the West Indies, but these are for use under canvas tents where there is a certain amount of leakage, and further, the work of fumigation is all carried out at night. This is in contrast to the practice in the West Indies, where hydrocyanic acid gas is used only in tight fumigating.

12. Fumigation Investigations in California, by R. S. Woglum. U.S. Dept. Agric., Bur. Entom., *Bulletin* 79, 1909.

The author finds that 1 oz. to 1¼ oz. acid to 1 oz. cyanide is sufficient to bring about complete reaction and a liberation of the full amount of gas. He states that the amount of water used by different operators varies from two to eight times the amount of acid (by bulk), the majority using about 3 to 4 parts of water to 1 of acid.

13. Fumigation of Apples for the San José Scale, by A. L. Quaintance. U.S. Dept. Agric., Bur. Entom., *Bulletin* 84, 1909.

This bulletin gives the result of fumigating apples (fruits) with hydrocyanic acid gas for the destruction of the San José scale. It also gives summaries of laws of different countries with regard to imported plants, fruits, etc.

14. Requirements to be complied with by nurserymen or others who make interstate shipments of nursery stock, by A. F. Burgess. U.S. Dept. Agric., Bur. Entom., Circular 75, revised to July 1, 1909.

15. The Fumigation of Nursery Stock in Louisiana, with hydrocyanic acid gas, by Wilmon Newell.
Circular 29, in 3rd Biennial Report, Louisiana State Entomologists, 1908-9.

This circular gives particulars of hydrocyanic acid gas fumigation in Louisiana, construction of fumigating houses and boxes and results of recent experiments, and also recommends the use of ⅝-oz. to 1 oz. of cyanide per cent. (for dormant plants) and 2 parts of acid and 4 of water to 1 of cyanide.

16. The State Crop Pest Law of Louisiana, and the Rules and Regulations of the State Crop Pest Commission, in effect, Nov. 1, 1909. Circular No. 32 of the State Crop Pest Commission of Louisiana, 1909.

This circular is explained by its title. The laws and rules and regulations are very comprehensive and give the Commission power to deal with the San José scale, sugar-cane borer, Texas cattle tick, and several dangerous insect and fungoid enemies of fruits.

17. The *West Indian Bulletin*:—The article entitled 'Legislation in the West Indies for the control of Pests and Diseases of Imported Plants', which was referred to at the beginning of the present article, contains reference to the papers which had appeared in previous numbers of that publication on the subject.

18. The *Agricultural News*:—Articles on the disinfection of cotton seed have appeared as follows:—Vol. III, pp. 117 and 149; Vol. IV, p. 101; Vol. V, p. 214; Vol. VI, p. 183.

19. The Chemistry of Bordeaux Mixture, by Spencer U. Pickering, F.R.S., *Trans. Chem. Soc.*, Dec., 1907.

An account of this paper appears in the Summary of the Eighth Report of the Woburn Experimental Fruit Farm, 1908.

20. The *International Sugar Journal*, March 1910, refers to experiments in Hawaii with Pickering's Bordeaux in comparison with the normal mixtures. See also *Hawaiian Sugar Planters' Monthly*, Nov. 1909.

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